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INSTRUMENTS

INSTRUCTION MANUAL

MODEL 2700-A DIGITAL SYSTEM

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AN ACCURATE, SOLID STATE,
DIGITAL INSTRUMENT FOR TIME,
FREQUENCY AND RELATED MEASUREMENTS

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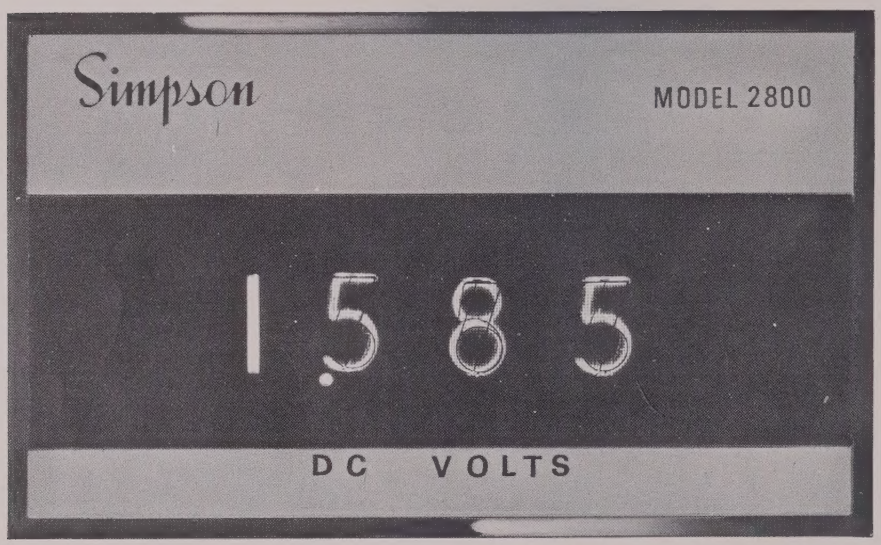

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INSTRUMENTS

INSTRUCTION MANUAL MODEL 2700-A DIGITAL SYSTEM

AN ACCURATE, SOLID STATE,
DIGITAL INSTRUMENT FOR TIME,
FREQUENCY AND RELATED MEASUREMENTS

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FIGURE 1-1

MODEL 2700 DIGITAL SYSTEM

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SECTION 1
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 The Model 2700 Digital System is an integrated circuit 4-digit precision instrument suitable for use in laboratory, production, servicing, and computer interface applications. It is also widely used as a replacement for analog-type instruments and panel indicators to measure dc voltages from 100 microvolts to 1000 volts with 0.05% (of reading) accuracy. Plug-in units are available to increase the usefulness of the instrument. (See Section 1-8)

1-3 DESCRIPTION

1-4 The Model 2700 is designed to measure dc voltages from 100 microvolts to 1000 volts with an accuracy of ±0.05% of reading ±1 digit at operating temperatures between +10° C and +40° C. The analog to digital technique utilized in the Model 2700 is ramp comparison. Maximum reliability and a minimum number of components are achieved by maximum utilization of monolithic integrated circuits. The instrument maintains its rated accuracy for overrange voltages of 10% on all ranges. Polarity of the voltage being measured is automatically indicated. Measurement sampling time is controlled by the front panel DISPLAY TIME switch. Selection of range is controlled by the DC VOLTAGE RANGE switch on the front panel.

1-5 Components in the Model 2700 are located for ease of maintenance and increased instrument ruggedness. Nearly all circuit components are mounted on etched circuit boards, providing ready access to test points and substitution capability of entire assemblies. The instrument enclosure is desgned for easy adaptability to a standard rack mounting configuration. Display effectiveness of the readout tubes is achieved by the use of a baffle and a polarized filter to minimize reflections from external light sources and internal tube glow.

1-6 SPECIFICATIONS

1-7 Table 1-1 lists electrical specifications for the Model 2700 Digital System.

TABLE 1-1 SPECIFICATIONS

DC Voltage Ranges:	.9999 V full scale 9.999 V full scale 99.99 V full scale 999.9 V full scale
Accuracy:	±0.05% of reading ±1 digit
Input Impedance:	10.2 Megohms constant
Resolution:	100 microvolts on the .9999 V range
Overrange:	Rated accuracy to 110% full scale on all ranges
Polarity:	Automatic with indication
Response Time:	Less than 5 seconds
Sampling Rate:	Variable, from 5 samples per second to HOLD condition
Overload Protection:	500 VDC minimum
Temperature Range:	Rated accuracy at +25° C ±5° C without calibration adjustment. Unit can be calibrated to rated accuracy over the temperature range of +10° C to +40° C with control adjustments.
Floating Input:	Up to 500 VDC above or below GND
Noise Rejection:	(a) common mode — with 1K ohm unbalance in either input lead DC — 120 db 60 Hz — 90 db (b) Normal mode 60 Hz — 60 db
Power Requirement:	115/230 Volts AC ±10% 50-60 Hz, approximately 15 Watts.
Weight:	Less than 8 pounds
Size:	4" high, 8-1/4" wide, 11" deep (not including panel controls).

1-8 PLUG-IN UNITS

The following Plug-In Units are available for use with Model 2700 basic unit.

a. Model 2700-01 RESISTANCE ADAPTER

b. Model 2700-02 A.C. VOLTAGE ADAPTER

c. Model 2700-03 D.C. CURRENT ADAPTER

d. Model 2700-05 D.C. VOLTAGE AUTO RANGING ADAPTER (not interchangeable after installation)

Instruction manuals for plug-ins are supplied with the plug-in units.

1-9 OPTIONS AVAILABLE

a. Rear input connector: Provides convenient input connections on rear of the unit for rack mounting configuration.

b. BCD output: Connector on the rear of the unit provides the BCD 1-2-4-8 output of all four decade counters with a print command signal.
Logic zero is equal to or less than +0.4 volts.
Logic one is equal to or greater than +2.4 volts.

c. External sample command: Connector on the rear of the unit requires a contact closure action for activating the sampling cycle.

1-10 ACCESSORIES AVAILABLE

a. Rack mounts: Adapt instrument to a standard rack mounting configuration, 5¼" high and 19" wide. Provides capability of mounting either one or two Model 2700's side by side, or a 2700 next to a 2724/5.

SECTION II
UNPACKING AND INSTALLATION

2-1 INCOMING INSPECTION

2-2 Examine the external covering for obvious damage. Notify the shipper if there is any sign of external damage. If not, remove the covering and again examine for obvious damage from shock, water leakage, or other faults. It should be physically free of marks or scratches and in perfect electrical order upon receipt. Also check for any accessories which may be indicated on the packing slip, and test the electrical performance of the instrument using the procedure outlined in paragraph 5-3.

2-3 POWER SOURCE REQUIREMENTS

2-4 The Model 2700 can be operated from a 115 or 230 volt, 50 to 60 Hz AC source. (Special 400 Hz unit is available upon request.) Primary power requirements are connected internally as indicated by the rear panel label. Before plugging the Model 2700 into the power source, check that the designation on the label matches the line voltage of your power source. The unit draws approximately 15 watts.

2-5 MOUNTING INSTRUCTIONS

2-6 The instrument can be set horizontally with the handle positioned along the top as shown in Fig. 2-1. A convenient sloping position can be obtained by swinging the handle under the instrument and locking it in place with the handle lock as shown in Fig. 2-2.

2-7 Relay rack adapters are available to mount either one or two instruments in a standard 5¼" x 19" panel area. See Figs. 2-3 and 2-4. The unit will operate properly in any position.

FIGURE 2-1 HORIZONTAL POSITION

FIGURE 2-2 SLOPING POSITION

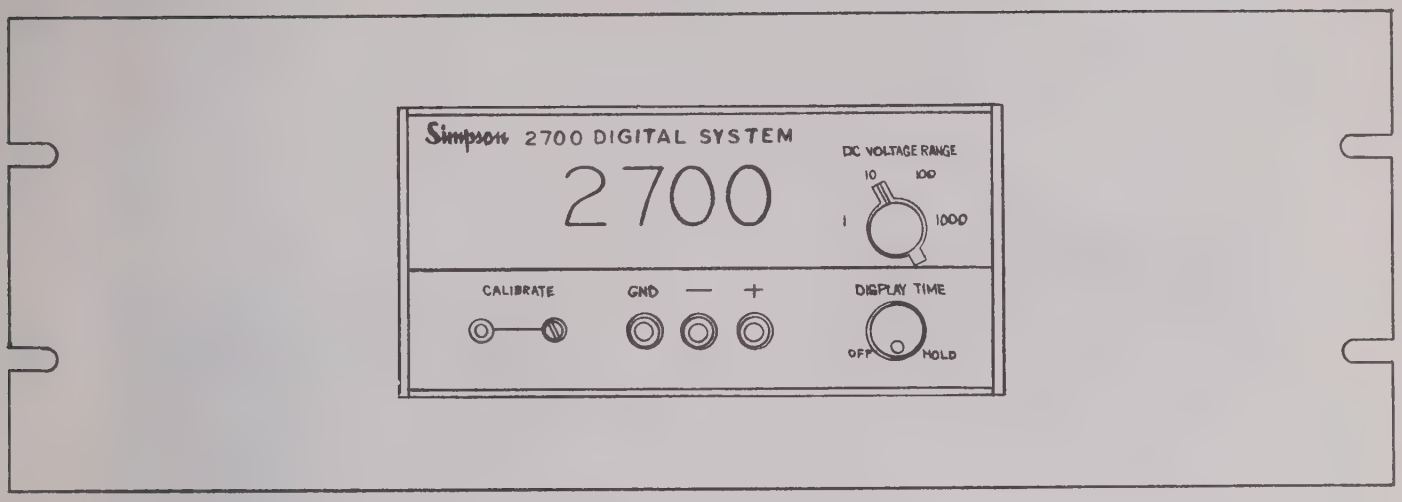


FIGURE 2-3 SINGLE RELAY RACK ADAPTER

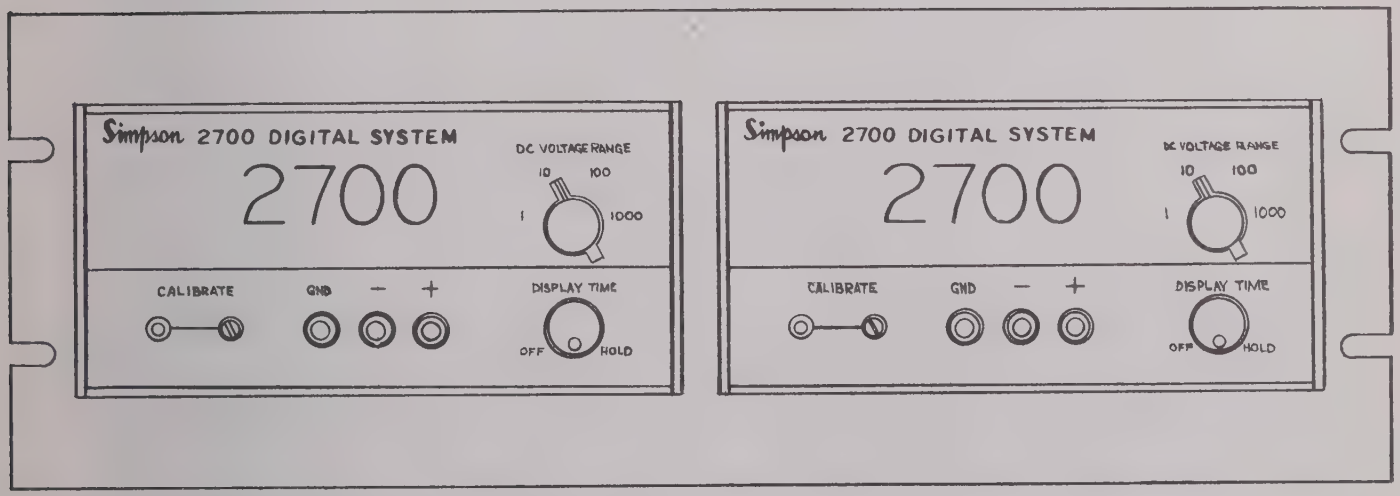


FIGURE 2-4 DUAL RELAY RACK ADAPTER

SECTION III
OPERATING INSTRUCTIONS

3-1 GENERAL

3-2 The Model 2700 will measure dc voltages from 0 to 999.9 volts to four significant figures. The unit can be operated with input signals 10% overrange with rated accuracy. Automatic polarity indication and variable sampling rate are standard features of this instrument.

3-3 FRONT AND REAR PANEL DESCRIPTION

3-4 Description of front and rear panel controls and indicators is given in Figure 3-1.

3-5 OPERATING INSTRUCTIONS

3-6 Figure 3-2 outlines the turn on procedure.

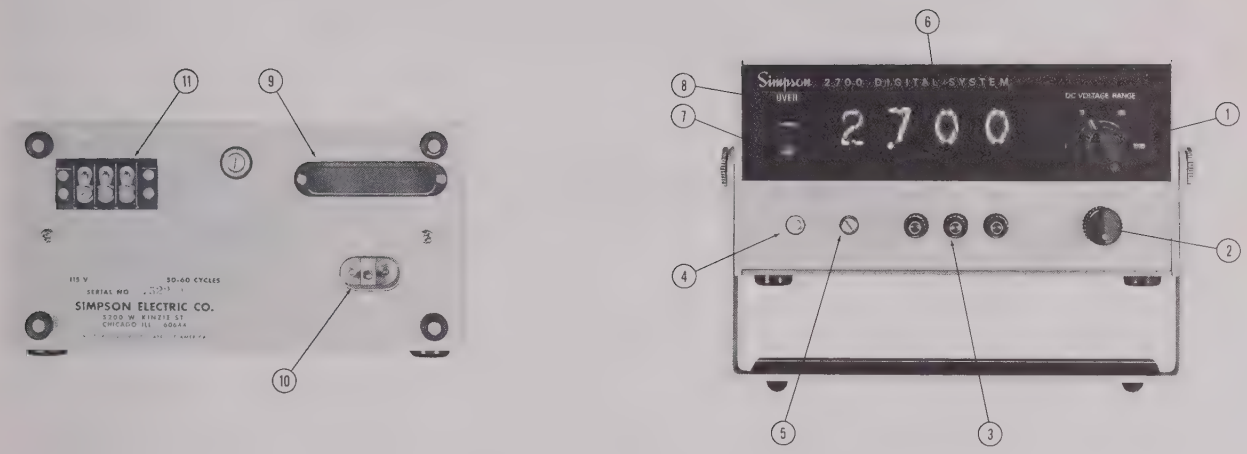


FIGURE 3-1 FRONT AND REAR PANEL DESCRIPTION

1. DC VOLTAGE range selector: Selects one of four dc voltage ranges: 1V, 10V, 100V, and 1000V. Each number represents the full scale capability of that range. Selector also controls the position of the decimal point.
2. DISPLAY TIME control: Applies primary power to the instrument and varies the instrument sampling rate and display time. The sampling rate can be varied from 5 samples per second to HOLD condition.
3. INPUT terminals: Input voltage is applied between the — and + terminals. The input signal can be referenced to chassis by shorting the GND terminal to one of the other two terminals.
4. CALIBRATION push-button switch: Depressing push-button displays the calibration voltage from an internal source.
5. CALIBRATION screwdriver adjust: Adjusts calibration for correct readout of the internal calibration voltage source.
6. READOUT DISPLAY: Indicates input or calibration voltage value. (Uses neon numerical glow tubes.)
7. POLARITY indicator: Indicates the polarity of the input voltage.
8. OVER indicator: Illumination indicates that the input voltage has reached or exceeded the full scale range.
9. BCD OUTPUT connector: Supplied with this unit as an option. The connector supplies the Binary-Coded-Decimal outputs of the four decade counters. The print command output is also available from this optional connector. (See Figure 3-3 BCD OUTPUT CONNECTIONS.)
10. AC POWER receptacle: Accepts the primary power cable supplied with the instrument.
11. REAR INPUT terminals: Supplied with this unit as an option. Serves the same function as the front panel INPUT terminals. (It is not practical to have both front and rear inputs wired simultaneously.)

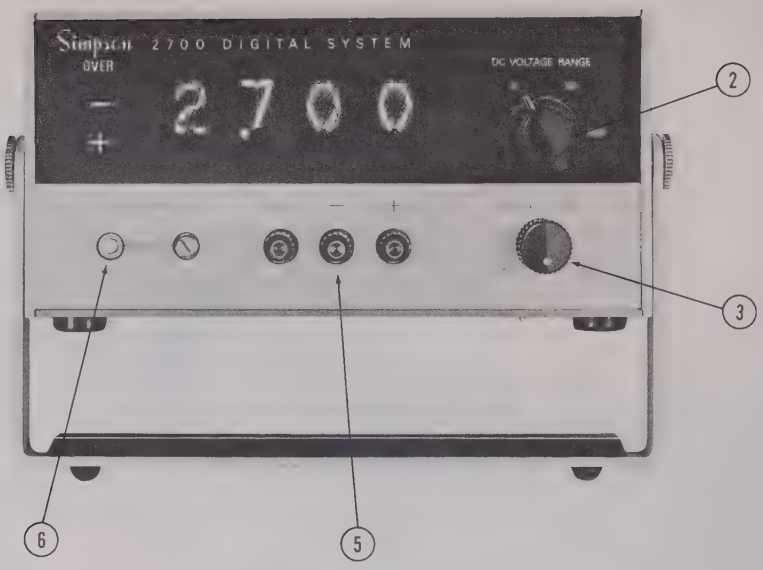


FIGURE 3-2 TURN ON PROCEDURE

1. Connect power cord to appropriate AC power receptacle. (See Figure 3-4 A.C. INPUT POWER CONNECTION.)
2. Set the DC VOLTAGE range selector to the 1 position.
3. Set the DISPLAY TIME control to mid-position. This turns on the power to the instrument and adjusts the sample rate to approximately two per second.
4. Allow the Model 2700 to warm up for approximately 30 minutes.
5. Short INPUT terminals. The readout display should indicate between −.0001 and +.0001. If the correct readout display is not obtained, refer to Section V, "Maintenance" for adjustment.
6. Depress the CALIBRATION pushbutton and adjust the CALIBRATION screwdriver adjust, (front panel) for the calibration voltage indication. The correct calibration voltage of the unit is indicated on the front panel and on the rear of the unit. (Decimal point position depends on the DC VOLTAGE range selector position, and does not affect this check.) If the correct indication can not be obtained, refer to Section V, Maintenance.
7. The instrument is now ready for measurements. In order to avoid excessive overload conditions, observe the proper full scale limits as indicated by the DC VOLTAGE range selector position.

CAUTION
DO NOT FLOAT THE INPUT MORE THAN 500 VOLTS DC ABOVE GROUND OR DAMAGE TO THE UNIT MAY RESULT!!!

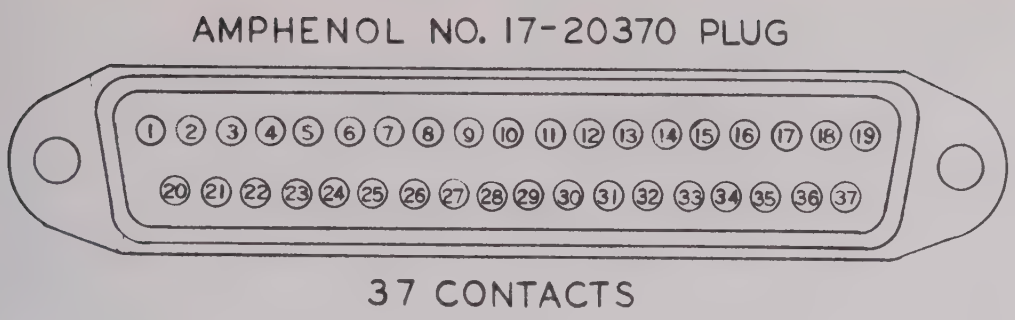


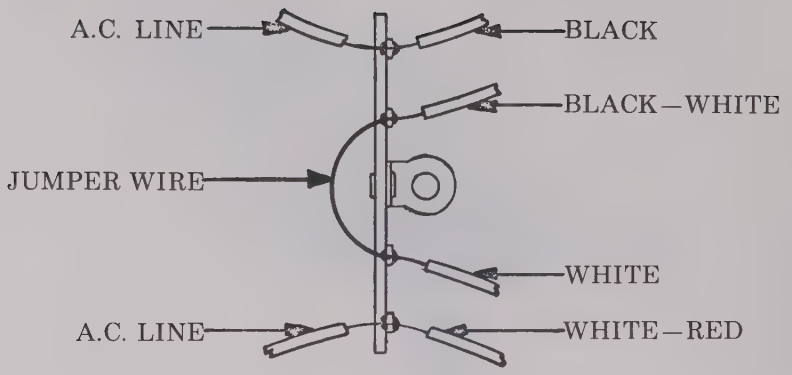
FIGURE 3-3 BCD OUTPUT CONNECTIONS

AMPHENOL #17-20370 PLUG

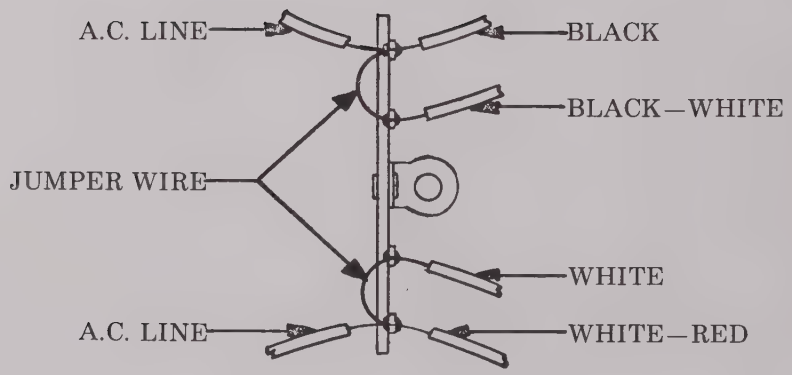
37 CONTACTS

CONTACT NUMBER	BCD OUTPUT	CONTACT NUMBER	BCD OUTPUT
1	DEC. 1	20	SAMPLE COMMAND
2	DEC. 2	21	SAMPLE COMMAND
3	DEC. 3	22	
4	DEC. 4	23	
5	A-3	24	D-4
6	B-3	25	C-4
7	C-3	26	B-4
8	D-3	27	A-4
9	VCC	28	GND.
10	—	29	PRINT COMMAND
11	A-2	30	D-1
12	B-2	31	C-1
13	C-2	32	B-1
14	D-2	33	A-1
15	—	34	
16	—	35	
17	—	36	
18	—	37	
19	—	—	—

For reference see Schematic Diagram Figure 5-8



115 VOLT



230 VOLT

FIGURE 3-4 INTERNAL A.C. INPUT POWER CONNECTION

SECTION IV
THEORY OF OPERATION

4-1 GENERAL

4-2 The Model 2700 Digital System is a solid state instrument employing a ramp type analog to digital conversion technique. During each sample process, a voltage which is proportional to the input voltage is compared with a linear internally generated ramp voltage. Upon coincidence of the ramp and input voltages the leading edge of a pulse is produced. In the same manner, the internal reference (ground) is also compared with the same ramp voltage producing the trailing edge of the same pulse. The time interval between the two edges or the width of the pulse is measured and displayed on the front panel readout tubes. Polarity is automatically indicated by the order in which these two edges are generated.

4-3 INPUT CIRCUITRY

4-4 ATTENUATOR

4-5 The Input Attenuator consists of four high precision fixed resistors and four variable resistors which are used for fine adjustments. The four attenuator outputs (one for each of the four DC voltage ranges) are selected by the positions of the RANGE switch. The attenuated voltage is applied to the input of the DC amplifier.

4-6 DC AMPLIFIER

4-7 The DC Amplifier is a solid state photocell chopper amplifier with a voltage gain of five. The DC voltage appearing at the input of the Amplifier is converted to AC by a series-shunt chopper at a rate fixed by the neon astable multivibrator. The resulting AC signal is then coupled to the AC amplifier. The amplified signal is then coupled to the input of the DC amplifier, through a second photo-chopper and an RC filter. The output of the DC amplifier is connected into the Input Comparator through an RC filter.

4-8 CONTROL CIRCUITRY

4-9 DISPLAY TIME CONTROL

4-10 The Display Time Control consists of a unijunction relaxation oscillator followed by a monostable multivibrator. The sample rate or the display time of 5 samples per second to display HOLD is controlled by the DISPLAY TIME potentiometer on the front panel. The pulse generated by the unijunction transistor initiates the RESET to the Decade Counters and starts the ramp.

4-11 RAMP GENERATOR

4-12 The Ramp Generator, which is a basic Miller Integrator, produces a linear ramp voltage which decreases from +10 volts to −10 volts. The ramp voltage is initiated by the sample rate pulse from the unijunction oscillator. The ramp is connected directly to the inputs of both voltage comparators and is used to scan the voltage levels of the inputs for coincidence.

4-13 INPUT COMPARATOR

4-14 The Input Comparator compares the output voltage of the DC amplifier with the ramp voltage. The Comparator circuit consists of a differential amplifier followed by a monolithic high speed Differential Comparator. Upon voltage coincidence of the input voltages, the output of the comparator changes state and returns to its normal state at the completion of the ramp signal.

4-15 ZERO COMPARATOR

4-16 The Zero Comparator is identical in construction to the Input Comparator and is used to compare the reference (ground) with the ramp voltage. The output of the comparator changes state whenever the ramp voltage crosses the reference point and returns to its normal state at the completion of the ramp signal.

4-17 LOGIC CIRCUITRY

4-18 EXCLUSIVE OR GATE

4-19 The EXCLUSIVE OR gate consists of our 2-input integrated circuit NAND gates and produces a pulse whoe duration is equal to the time at which the two comparator outputs are in opposite states. The output pulse width, which is proportional to the input voltage, is digitized by the gating of the 1 MHz oscillator signal.

4-20 DECADE COUNTER

4-21 The four monolithic integrated circuit Decade Counters totalize the oscillator pulses to provide a numerical readout on the readout tubes. Each decade counter consists of four flip-flops. A combination of output levels from the flip-flops represent one of ten decimal digits when the binary coded decimal (BCD) weights 1, 2, 4 or 8 as assigned to the one state of each flip-flop. For example, if flip-flops A, B, C, D are weighted 1, 2, 4 and 8 respectively, and if A and D are in the zero state and B and C are in the one state, the decimal digit represented is $0+2+4+0 = 6$. A decimal digit greater than 9 is not possible because of the internal connections of the four flip-flops.

4-22 DECODER/DRIVER

4-23 As the name implies, the monolithic integrated circuit Decoder/Driver performs two functions: to convert the outputs of the Decade Counters from a binary number to a decimal number and to serve as high voltage drivers for the readout tubes. Four lines of the BCD 1, 2, 4, 8 are connected as inputs to the Decoder/Driver and ten lines are connected to the ten cathodes of the readout tubes as outputs which represent the ten decimal numbers for display. The number to be displayed in the readout tube is determined by the low level output from one of the ten outputs from the Decoder/Driver.

4-24 POLARITY DETECTOR

4-25 The Polarity Detector consists of an integrated circuit flip-flop and two transistor lamp drivers. The polarity of the input voltage is determined by the output state of the flip-flop, which is derived from the output state of the Input Comparator.

4-26 OVERRANGE DETECTOR

4-27 The Overrange Detector consists of an integrated circuit flip-flop and a transistor driver. The flip-flop is reset at the beginning of each sampling pulse, and is set to the overrange condition when the carry pulse from the most significant digit decade counter is generated during the counting cycle.

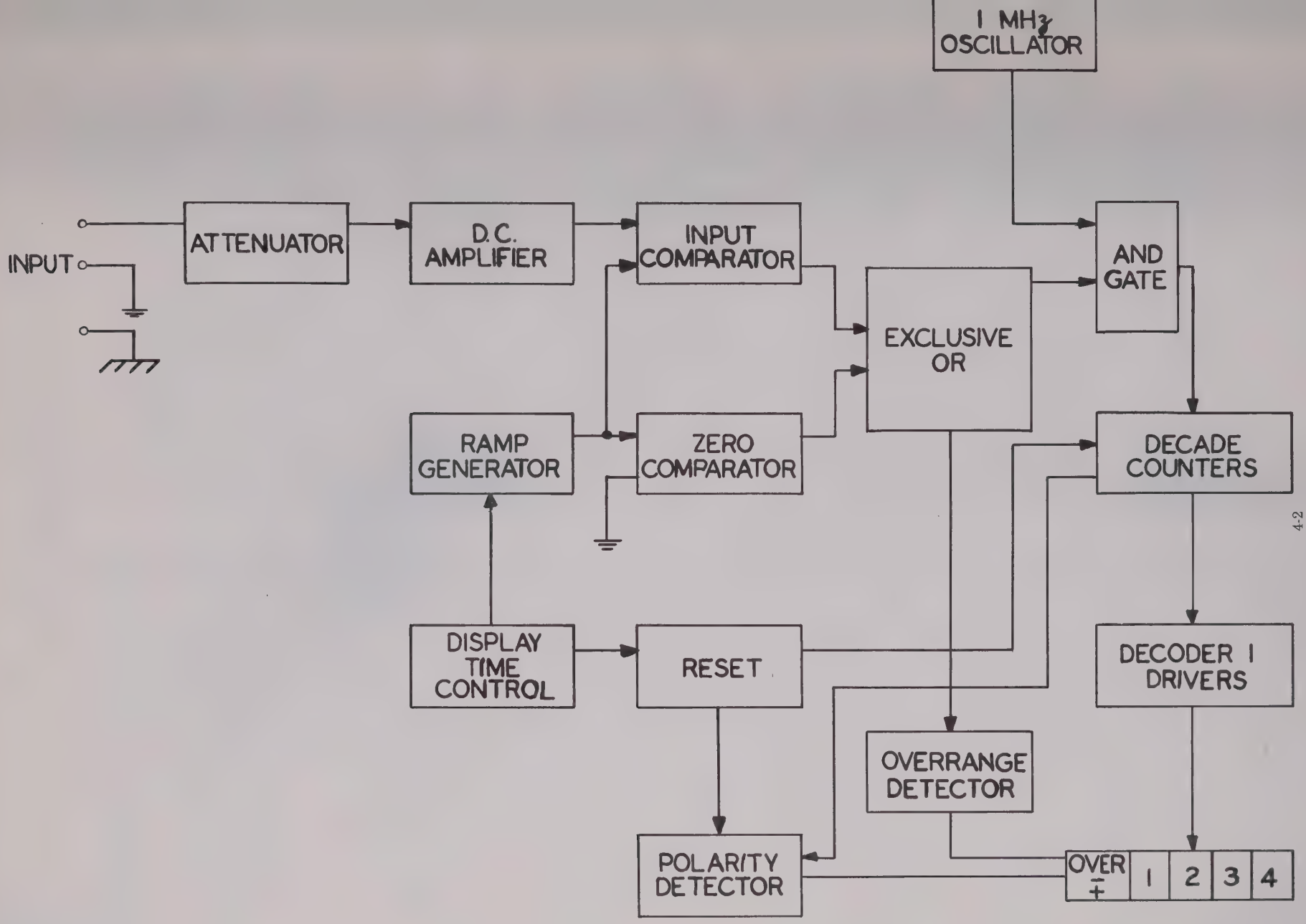


FIGURE 4-1 SIMPLIFIED BLOCK DIAGRAM

SECTION V

MAINTENANCE

5-1 REQUIRED TEST EQUIPMENT

5-2 Table 5-1 lists recommended test equipment required for checking performance, calibration, and trouble-shooting for the Model 2700. Test equipment other than that listed may be used if the specifications equal or exceed the required characteristics.

5-3 PERFORMANCE CHECK

5-4 The following performance check is used to verify the specifications of the Model 2700. It can be used upon receipt of a new instrument, for routine preventive maintenance and following repair. If the instrument fails to meet the performance check at any time, proceed to the appropriate calibration procedure to correct the malfunction.

5-5 VOLTAGE ACCURACY CHECK

a. Connect power cord to appropriate line voltage source as indicated on rear of unit.
b. Connect Model 2700 to the D.C. Standard as shown in Figure 5-1.
c. Turn on power to the Model 2700 and D.C. Standard allowing a 1 hour warm-up period.
d. Set the RANGE switch on Model 2700 to 1V.
e. With the D.C. Standard OUTPUT set to OFF, short the Model 2700 input terminals (— to +).
f. The Model 2700 should read —.0001 to +.0001. If adjustment is needed, follow the procedure outlined in Section 5-10 Zero Offset Adjustment.
g. Remove short from INPUT.
h. Depress CALIBRATE button and adjust CALIBRATE control for a display of the calibration voltage (printed on the rear panel calibration label).
i. Turn D.C. Standard ON.
j. Check Model 2700 against the Standard D.C. voltages listed in Table 5-2. The table can be used on the 10, 100, and 1000 volt ranges with proper decimal point placement.

TABLE 5-1 RECOMMENDED TEST EQUIPMENT

Instrument Types	Purpose	Required Characteristics	Recommended Model
DC Voltage Standard	Performance Check Calibration	Voltage Range: 0 - 1000 V Accuracy: ±0.01% of Reading	H.P. Model 741B
Oscilloscope	Calibration Trouble-shooting	Voltage Range: 1MV - 50V/CM	Tektronix 545B with Type D Plug-In
DC Voltage & Resistance	Calibration Trouble-shooting	Voltage Range: 0 - 1000 V Accuracy: ±0.01% (DC Vs) ±0.03% (OHMS) Input Impedance: 10M Ohms	Digital Voltmeter with Ohms Adapter

5-6 INSTRUMENT COVER REMOVAL

a. To remove the top cover turn the fastener, located on the rear of the instrument, 1/4 turn counter clockwise. Slide the cover approximately 1/2 inch forward and lift up. This procedure should be reversed to replace the cover.
b. To remove the bottom cover remove the four rubber feet. Lift the cover off the instrument. Note the position of the handle lock, and spring washer.
The parts should be assembled in reverse order to replace the cover.

5-7 ADJUSTMENT AND CALIBRATION

5-8 The following tests and adjustments should be made only after the Performance Checks, paragraphs 5-3 through 5-5, have shown the Model 2700 to be out of specifications.

5-9 POWER SUPPLY ADJUSTMENT AND VOLTAGE CHECKS

a. Connect power cord to an appropriate line voltage source as indicated on rear of unit.
b. Set DISPLAY TIME to HOLD.
c. Connect D.C. Voltmeter to Power Supply RED-BLUE (+200V) lead. (See Figure 5-2)
d. DC Voltmeter should read between +190 and +220V D.C.
e. Connect DC Voltmeter to Power Supply WHITE-RED (+150V) lead.
f. DC Voltmeter should read between +140 and +165V DC.
g. Connect DC Voltmeter and Oscilloscope to Power Supply BLACK (+20V) lead.
h. Set the Oscilloscope for 1 MV/CM.
i. Set the 20V potentiometer for a DC Voltmeter reading of +20.0 ±0.2V DC.
j. Oscilloscope should indicate less than 0.3 MV P-P AC.
k. Connect DC Voltmeter and Oscilloscope to Power Supply GREEN (—12V REGULATED) lead.
l. Set Oscilloscope for 5MV/CM.
m. DC Voltmeter should read between —11.0 and —13.4V DC. Oscilloscope should indicate less than 15.0MV P-P AC.
n. Connect DC Voltmeter and Oscilloscope to Power Supply ORANGE (+12V REGULATED) lead.
o. DC Voltmeter should read between +11.0 and +13.4V DC. Oscilloscope should indicate less than 15.0MV P-P AC.
p. Connect DC Voltmeter and Oscilloscope to Power Supply BLUE (—12V FILTERED) lead.
q. Set Oscilloscope for 1MV/CM.
r. DC Voltmeter should read between —11.5 and —13.4V DC. Oscilloscope should indicate less than 0.8MV P-P AC.
s. Connect DC Voltmeter and Oscilloscope to Power Supply VIOLET (+12V FILTERED) lead.
t. Set Oscilloscope for 1 MV/CM.

u. DC Voltmeter should read between +11.5 and +13.4V DC. Oscilloscope should indicate less than 0.3 MV P-P AC.

v. Connect DC Voltmeter and Oscilloscope to Power Supply YELLOW (+5V REGULATED) lead.

w. Set Oscilloscope for 20 MV/CM.

x. DC Voltmeter whould read between +4.9V and +5.8V DC. Oscilloscope should indicate less than 8 MV P-P AC.

5-10 ZERO OFFSET ADJUSTMENT

a. Remove D.C. Amplifier Plug-In.

b. Short connector pin 25, closest to rear of connector, to circuit ground.

c. Loosen Power Supply board and remove from chassis. (Note: Do not disconnect Power Supply.)

d. Set DISPLAY TIME control to minimum.

e. Set ZERO SET control for a reading of .0000 ±1 digit. (See Figure 5-3)

f. Replace Power Supply board and DC Amplifier Plug-in.

g. Short Model 2700 INPUT terminals.

h. Connect Oscilloscope to POINT "A" (See Figure 5-4).

i. Adjust Potentiometers A and B for a waveform of 4 Msec.

j. Set Potentiometers C and D to their mechanical center.

k. Adjust Potentiometer C for a reading between —.0001 and +.0001, ±1 digit.

l. Adjust Potentiometer D for a reading of .0000 ±1 digit.

5-11 D.C. VOLTAGE PLUG-IN CALIBRATION

a. Connect Digital Voltmeter to point AA (See Figure 5-5)

b. Set Digital Voltmeter Function switch to KΩ.

c. Set Digital Voltmeter Range switch to AUTO.

d. Adjust Potentiometer A for a reading of 10.160 ±1 digit.

e. Connect Digital Voltmeter to point BB.

f. Adjust Potentiometer B for a reading of 101.60 ±1 digit.

g. Connect Digital Voltmeter to point CC.

h. Adjust Potentiometer C for a reading of 1016.0 ±1 digit.

i. Connect Digital Voltmeter to point DD.

j. Adjust Potentiometer D for a reading of 10160.0 ±1 digit.

5-12 CALIBRATION

a. Connect Model 2700 power cord to an appropriate line voltage source as indicated on rear of unit.

b. Allow 1 hour warm up time.

c. Set the DISPLAY TIME control for approximately one reading per second.

d. Set RANGE switch to 1V.

e. Press CALIBRATE button.

f. Adjust CALIBRATE control for calibration number reading. The calibration number is located on the rear of the instrument.

g. Check calibration by applying .5000 volts from the D.C. Standard. The Model 2700 should read .5000 ±1 digit. If trouble is encountered see paragraph 5-13.

5-13 TROUBLESHOOTING

5-14 Make certain the difficulty cannot be removed by adjustment and calibration (paragraph 5-7) before attempting to troubleshoot the instrument.

5-15 To be certain that the trouble is not external to the instrument, check the set up being used when the difficulty was encountered.

5-16 Inspect the instrument for loose, burned, or broken components, loose connections and broken leads which would be a source of trouble.

5-17 The following list should be used to localize the difficulty to a particular circuit.

a. Simplified Block Diagram (Figure 3-1).

b. Schematic Diagrams (Figures 5-8).

c. Troubleshooting Chart (Table 5-3).

d. Typical Voltage Chart (Table 5-4)

e. Waveform Timing Chart (Figures 5-6)

f. Typical Waveforms (Figure 5-7)

5-18 POWER SUPPLY

5-19 If difficulty is encountered in the +200 Volt section of the power supply, check DIODES (D-107 and D-108), CAPACITOR (C101), and RESISTOR (R112).

5-20 If difficulty is encountered in the +150 Volt section, check the +200 Volt section, ZENER DIODES (D110 and D111), and RESISTOR (R112).

5-21 If difficulty is encountered in the +12 Volt Unfiltered section, check DIODES (D103 and D104), CAPACITOR (C103), RESISTORS (R116 and R117), ZENER DIODE (D115), and TRANSISTOR (Q107).

5-22 If difficulty is encountered in the +5 Volt section, check DIODES (D101 and D102), CAPACITOR (C104), RESISTOR (R119), ZENER DIODE (D116), and TRANSISTOR (Q108).

5-23 If difficulty is encountered in the +12 Volt Filtered section, check the +12 Volt Unfiltered section, RESISTOR (R118), and CAPACITOR (C108).

5-24 If difficulty is encountered in the —12 Volt Unfiltered section, check DIODES (D105 and D106), CAPACITOR (C102), RESISTORS (R113 and R114), ZENER DIODE (D119), and TRANSISTOR (Q106).

5-25 If trouble is encountered in the —12 Volt Filtered section, check the —12 Volt Unfiltered section, RESISTOR (R115), and CAPACITOR (C106).

5-26 For difficulties encountered in the +20 Volt section, use paragraph 5-9 Power Supply Adjustment and Voltage Checks, and Table 5-4 Typical Voltages. When a voltage deviates greatly from the value given in the chart, check all components in the area of the component where the extreme deviation was measured.

5-27 CONTROL BOARD

5-28 For difficulties encountered on the control board, use the Troubleshooting Chart (Table 5-3), the Waveform Timing Chart (Figure 5-6), and the Typical Waveforms (Figure 5-7).

5-29 D.C. AMPLIFIER BOARD

5-30 For difficulties encountered on the D.C. Amplifier Board use the Typical Voltage Chart (Table 5-4).

5-31 When difficulty is encountered with excessive count variances check the neon lamps for flickering. Check waveform at point "A" comparing it to the waveform in Figure 5-7, Typical Waveforms.

5-32 D.C. VOLTAGE PLUG-IN

No service should be required on the D.C. Voltage Plug-in other than an occasional resistance re-calibration (See Paragraph 5-11).

TABLE 5-2 ACCURACY LIMITS

DC Standard	Model 2700	
	Minimum	Maximum
.0000	−.0001	+.0001
.1000	.0998	.1002
.2000	.1998	.2002
.3000	.2997	.3003
.4000	.3997	.4003
.5000	.4996	.5004
.6000	.5996	.6004
.7000	.6995	.7005
.8000	.7995	.8005
.9000	.8994	.9006
1.0000	.9994	.0006*

*indicates OVERRANGE lamp should be lighted.

TABLE 5-3 TROUBLE-SHOOTING CHART

SYMPTOM	POSSIBLE CAUSE
1. Display not lit.	a. Line fuse (1/2A) b. Line switch c. Power transformer d. Power supply e. Instrument not plugged in
2. Display lit, no response to input.	a. Power supply b. Clock circuit (Q214, Q215 & Q216) c. Ramp generator (IC201) d. Ramp gate (IC205) e. Clock gate (IC206) f. D.C. amplifier plug-in g. Calibrate switch
3. Counts continuously, reset working.	a. Input and zero comparator circuits (Q206, Q207, Q208 & IC202) (Q209, Q210, Q211 & IC203) b. Comparison gates (IC204) c. Clock gate (IC206)
4. Counts continuously, no reset.	a. Same as No. 3 above b. Reset gates (IC206)
5. Random counting, no reset	a. Reset gates (IC206)

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TABLE 5-4 TYPICAL VOLTAGES

POWER SUPPLY VOLTAGES

−12V CIRCUIT	
Q106 collector	−25V
Q106 base	−13V
Q106 emitter	−12.5V
+12V CIRCUIT	
Q107 collector	+ 25V
Q107 base	+ 13V
Q107 emitter	+ 12.5V
+5V CIRCUIT	
Q108 collector	+ 8.4V
Q108 base	+ 6.2V
Q108 emitter	+ 5.5V
+20V CIRCUIT	
Q101 collector Q102 emitter	+29V
Q101 base	+19.7V
Q101 emitter	+19.1V
Q102 base Q105 collector	+28.5V
Q103 collector Q105 base	+ 9.8V
Q103 base	Variable + 6.2V
Q103 emitter Q104 emitter	+ 5.5V
Q104 collector Q105 emitter	+ 9.2V
Q104 base	+ 6.2V
+ 200V CIRCUIT	
R122 & C101A junction	+ 210V
R122 & R112 junction	+ 200V
+ 150V CIRCUIT	
R122 & D110 junction	+ 150V
D.C. AMPLIFIER VOLTAGES	
Q401 gate	−1.75V
Q401 source	− .03V
Q402 collector	−1.76V
Q402 base	−5.6 V
Q402 emitter	−6.2 V

NOTE:
The preceding voltages are typical values and will vary with component tolerances and line voltage.

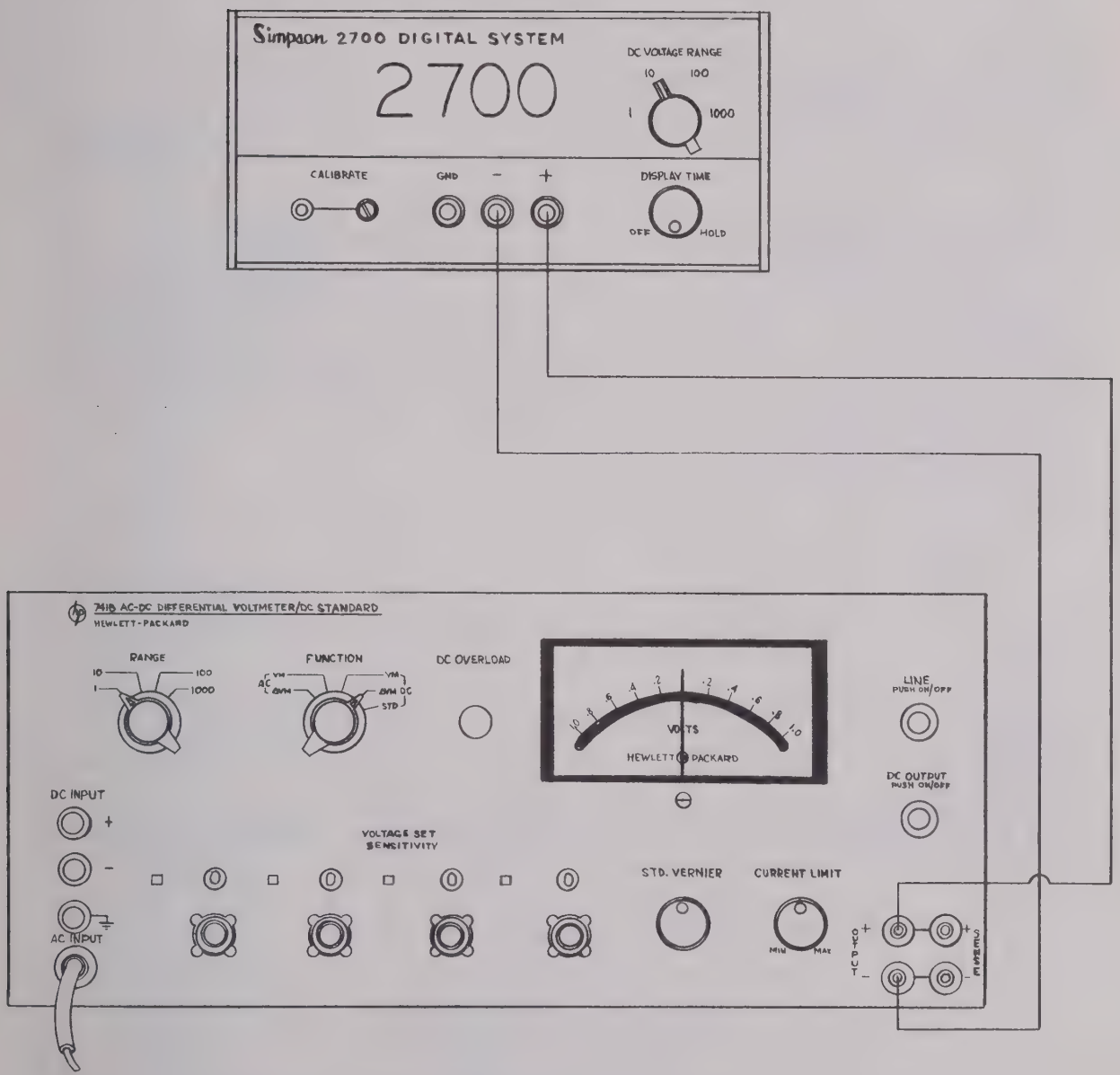


FIGURE 5-1 CONNECTION TO D.C. STANDARD

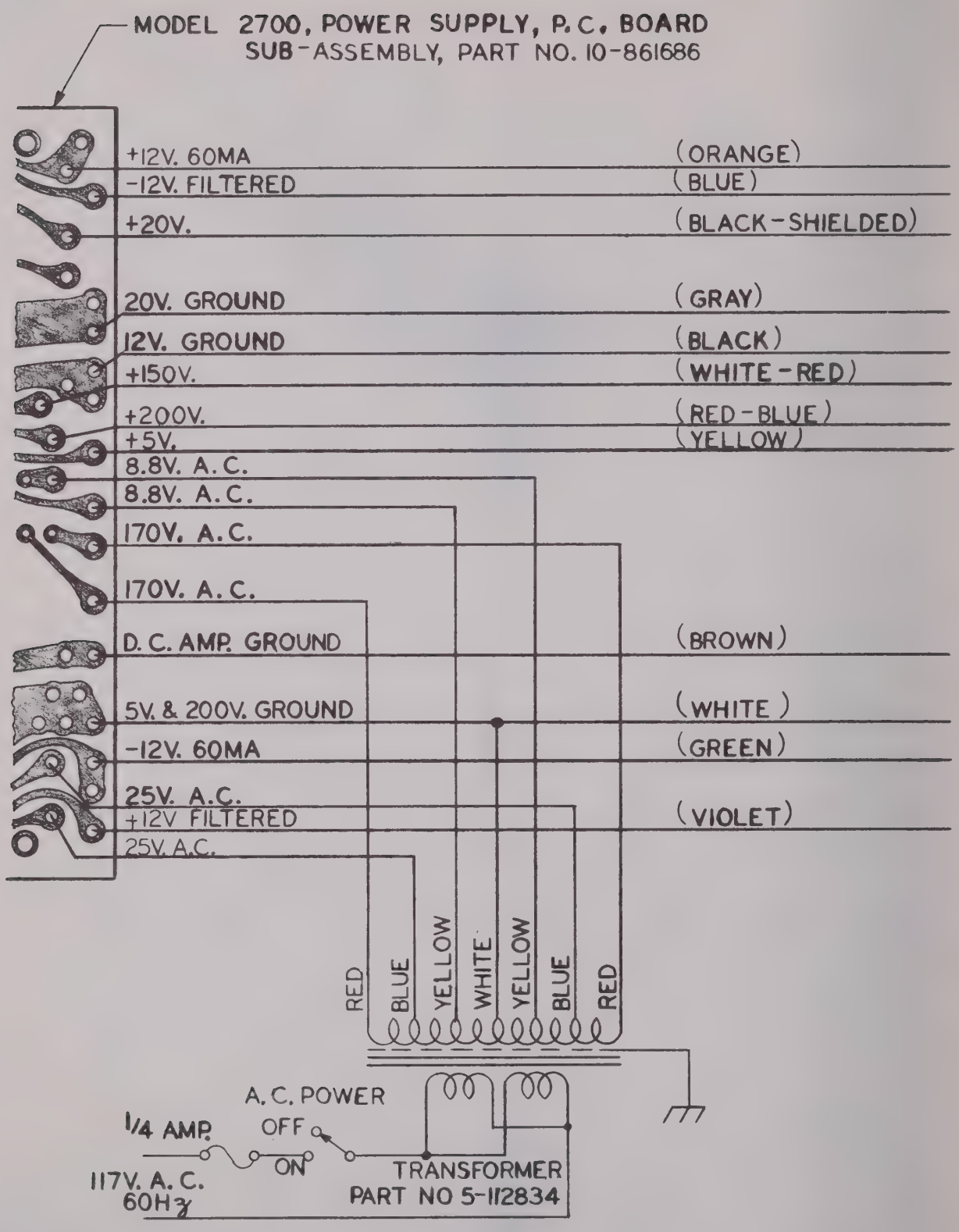


FIGURE 5-2 POWER SUPPLY

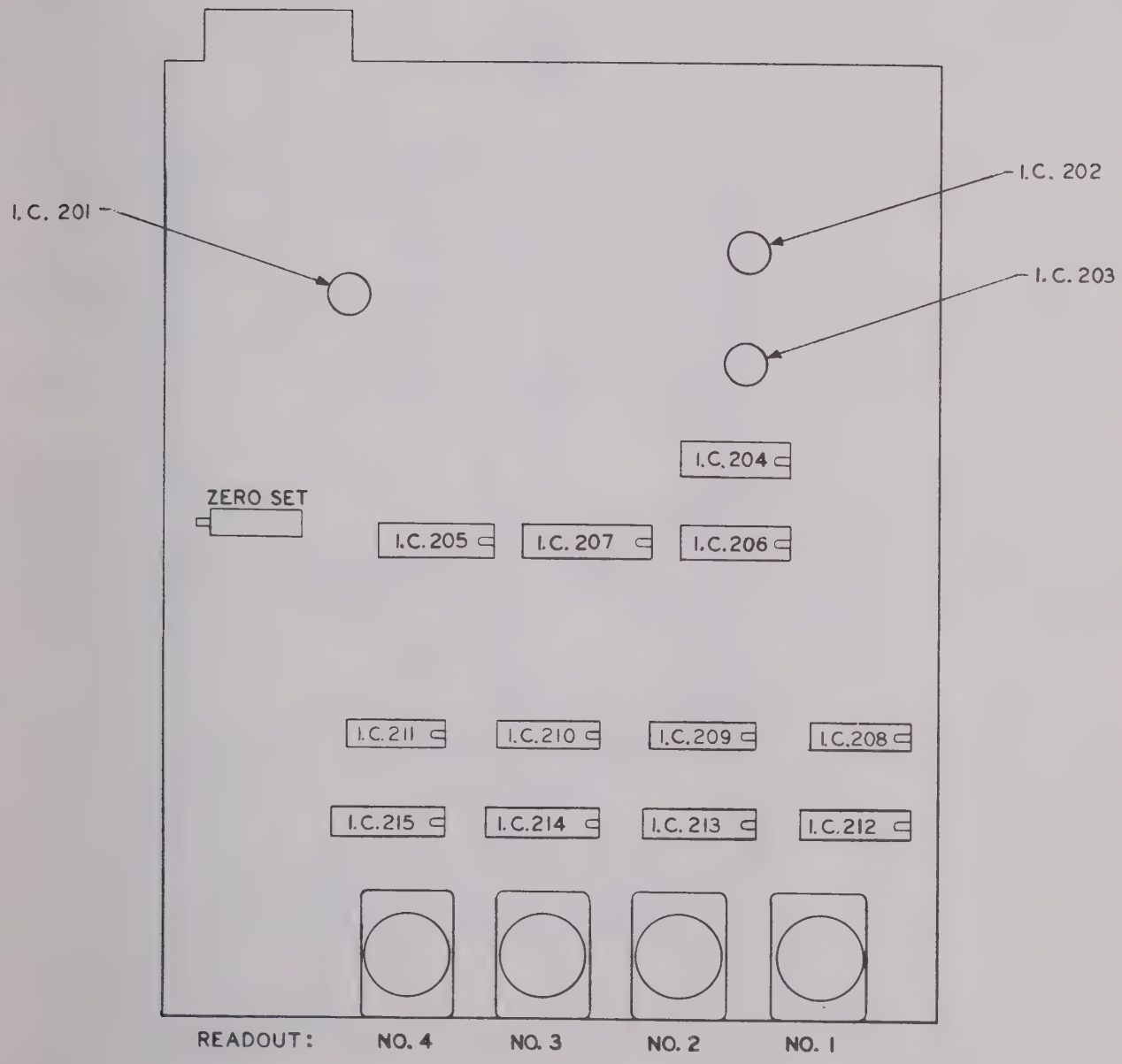
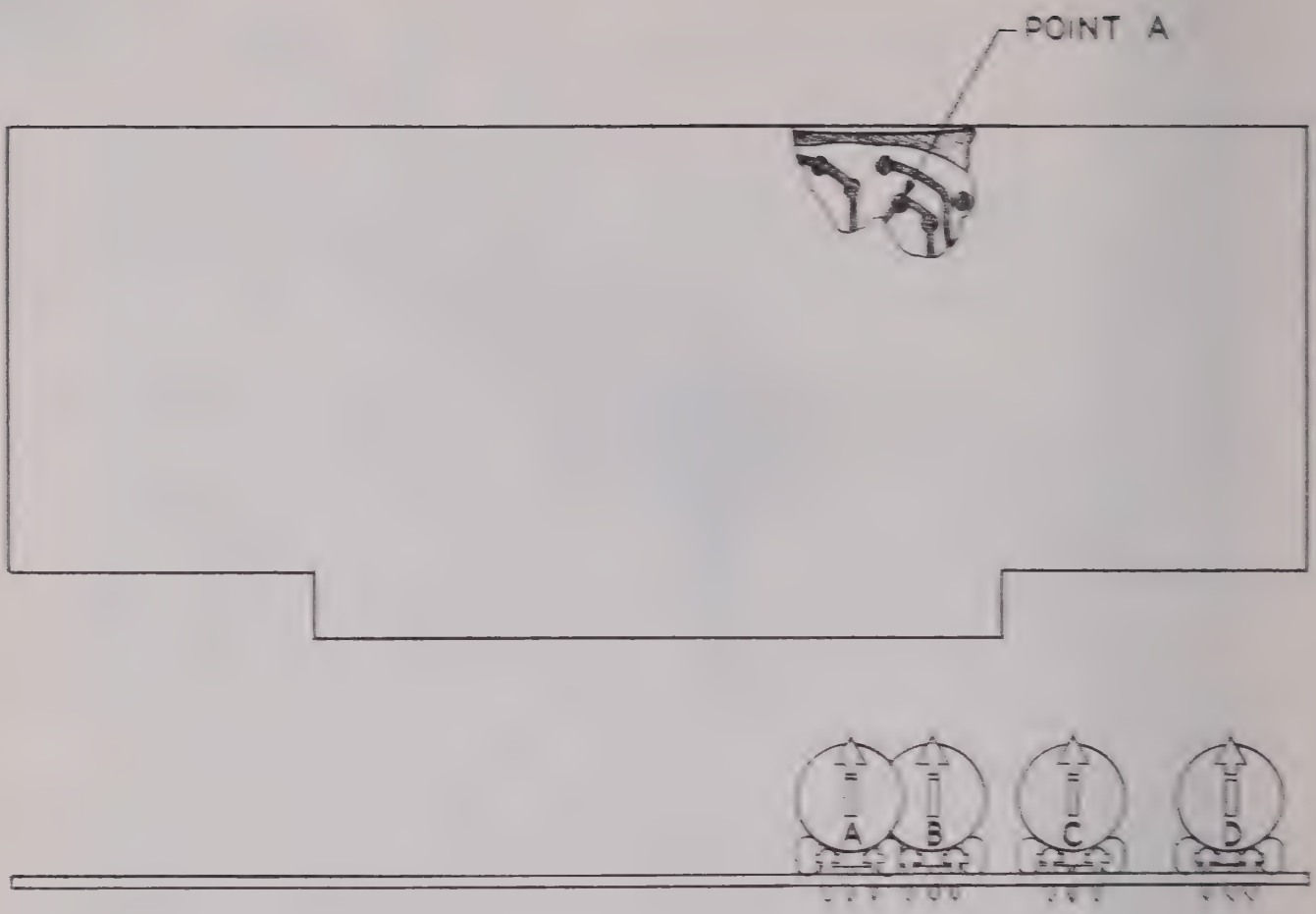


FIGURE 5-3 CONTROL BOARD TRANSISTOR-TRANSISTOR LOGIC



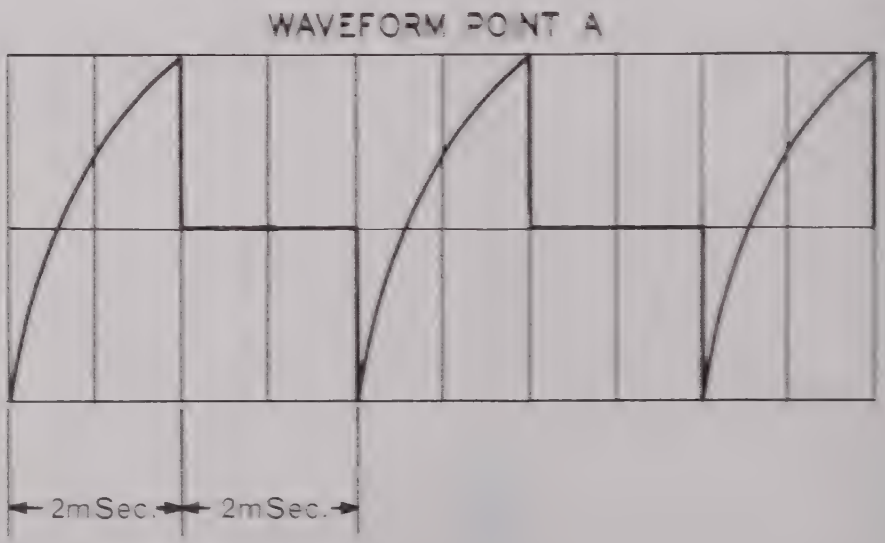


FIGURE 5-4 D.C. AMPLIFIER ADJUSTMENTS

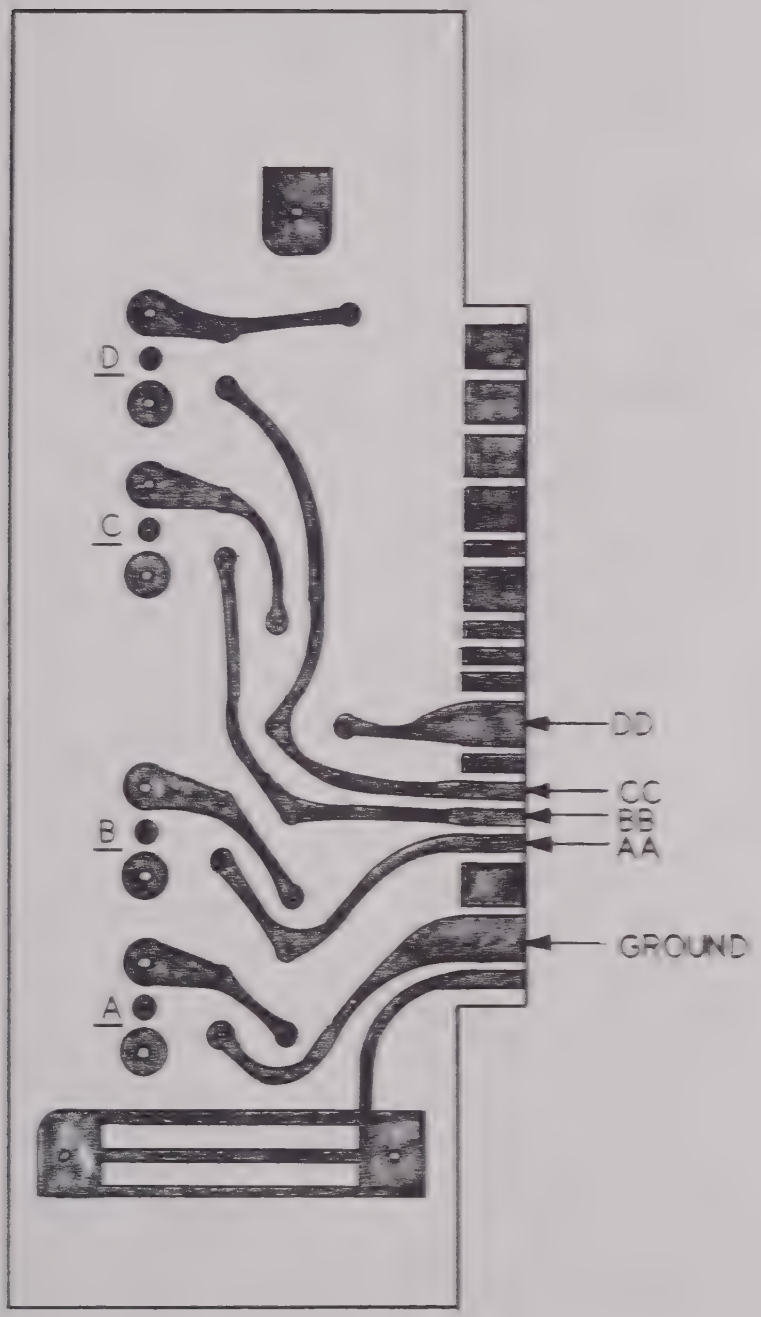


FIGURE 5-5 D.C. VOLTAGE PLUG-IN

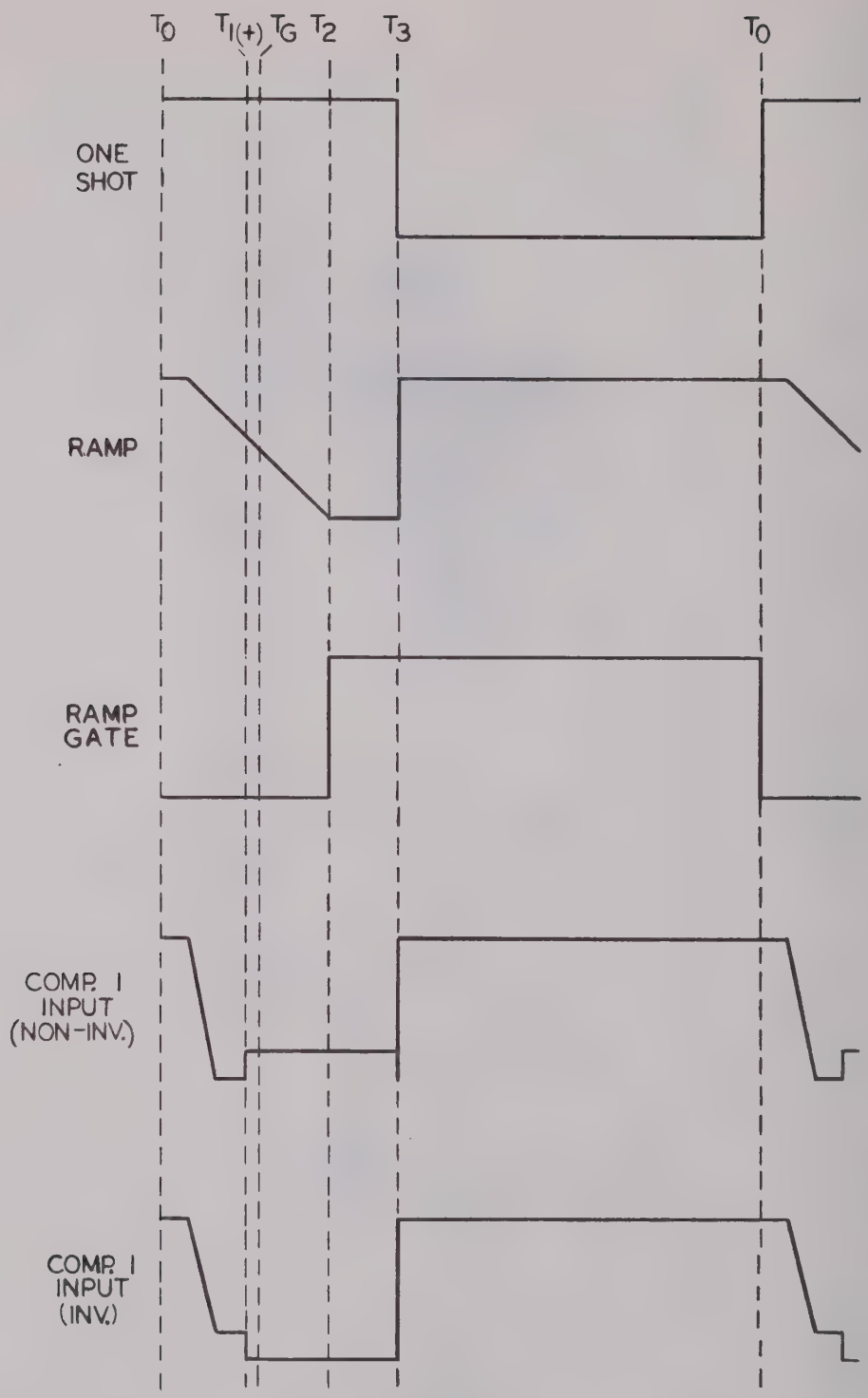


FIGURE 5-6 TIMING CHART

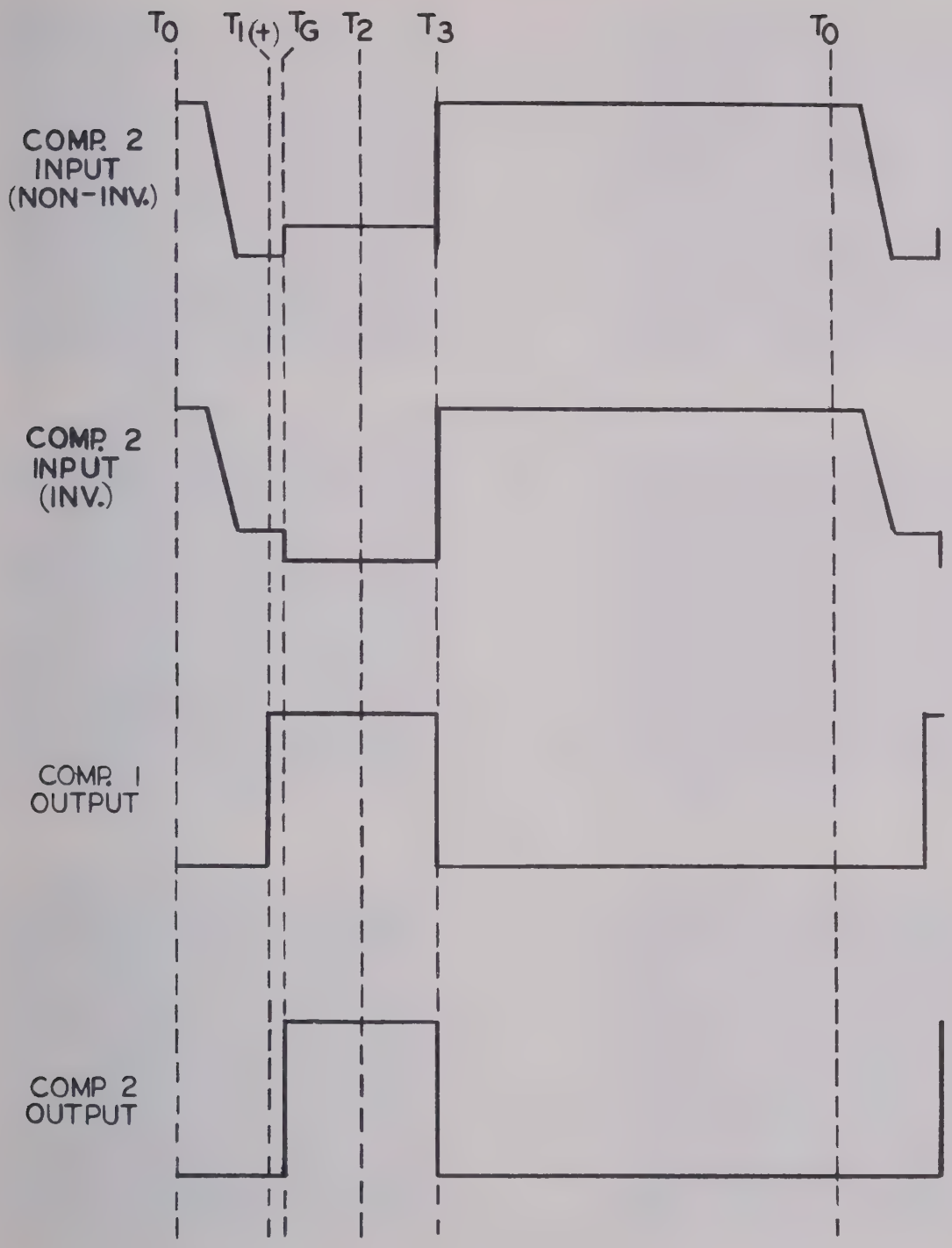


FIGURE 5-6 TIMING CHART (Continued)

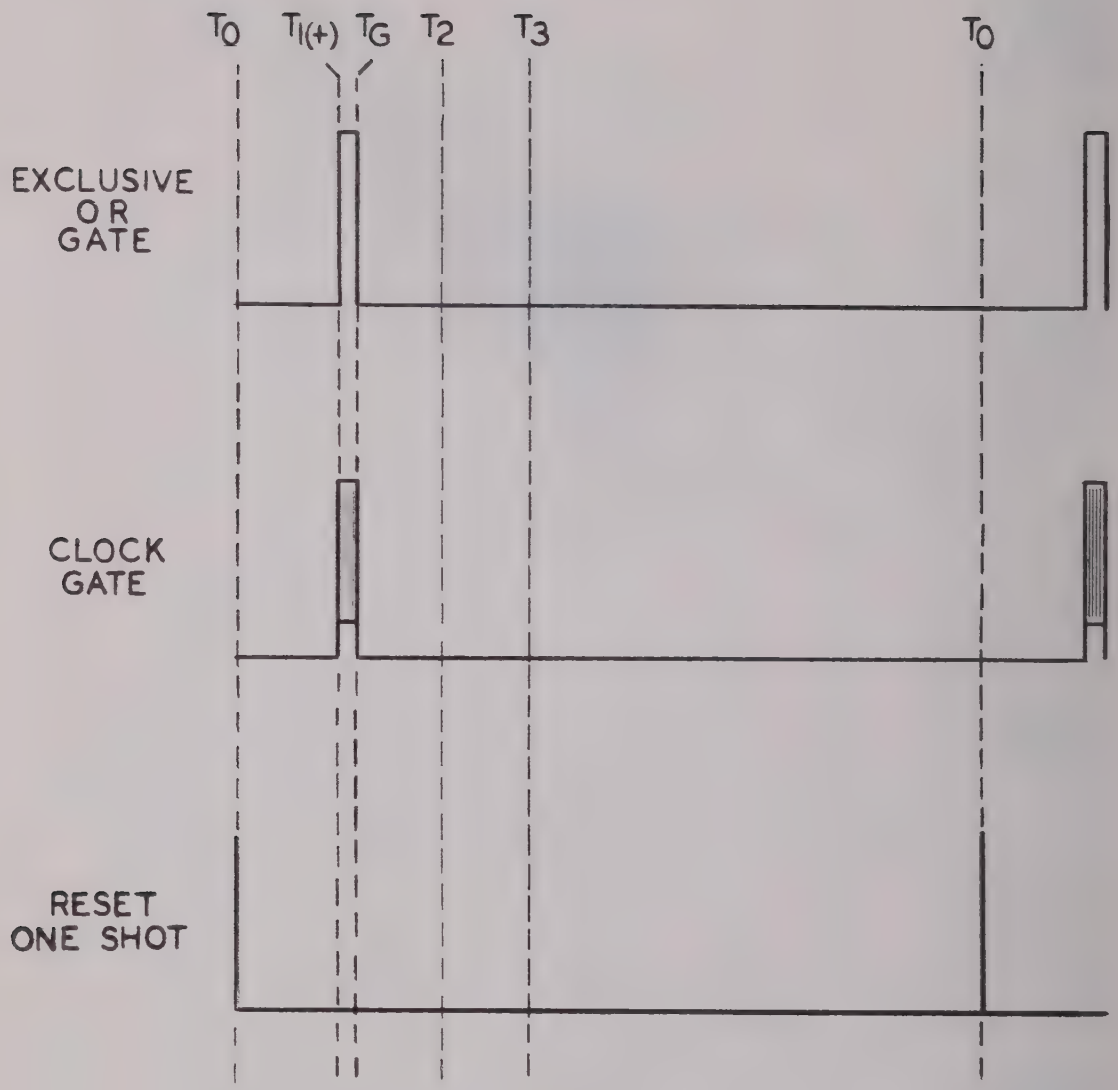
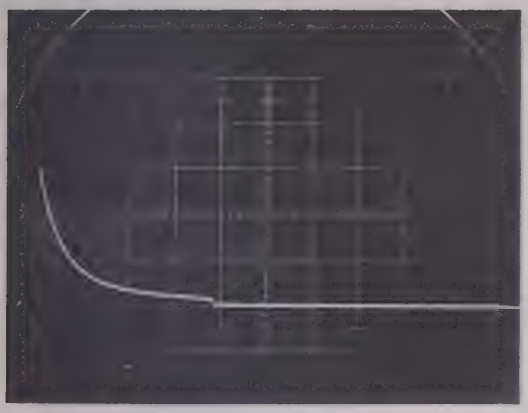
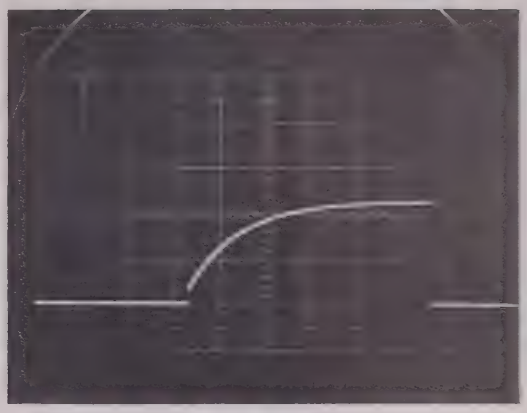


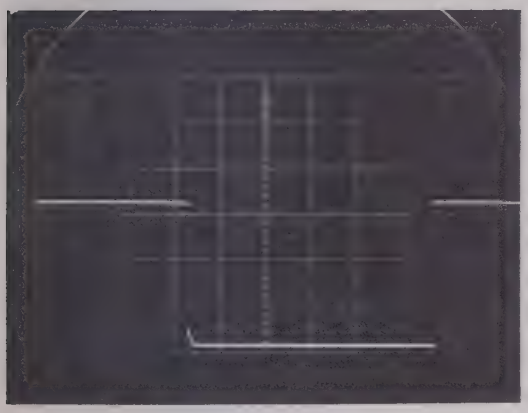
FIGURE 5-6 TIMING CHART (Continued)



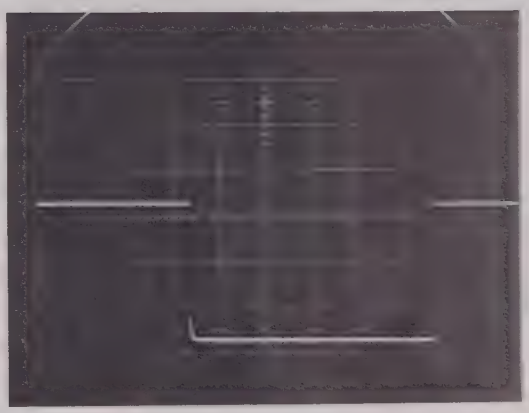
1. UNIJUNCTION PULSE
Q 201, Base 1
2V/CM-.5m Sec/CM



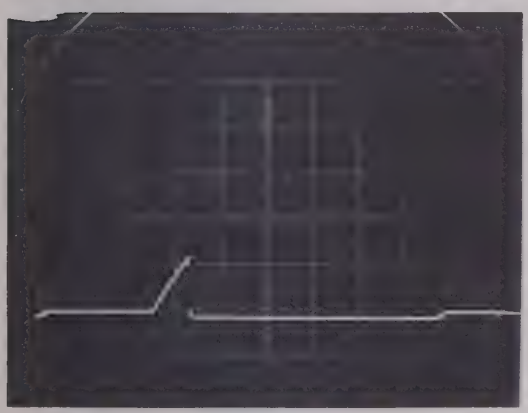
2. Q 202, Collector
5V/CM-20m Sec/CM



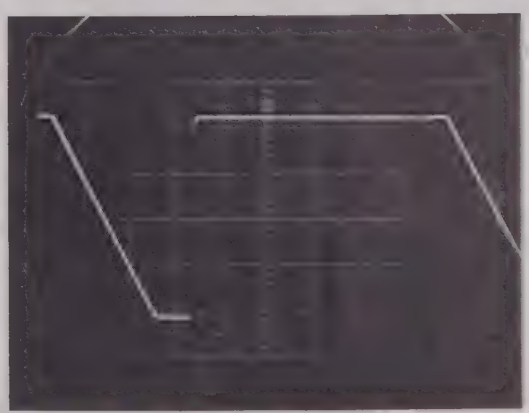
3. Q 203, Collector
5V/CM-20m Sec/CM



4. Q204, Emitter
5V/CM-20m Sec/CM

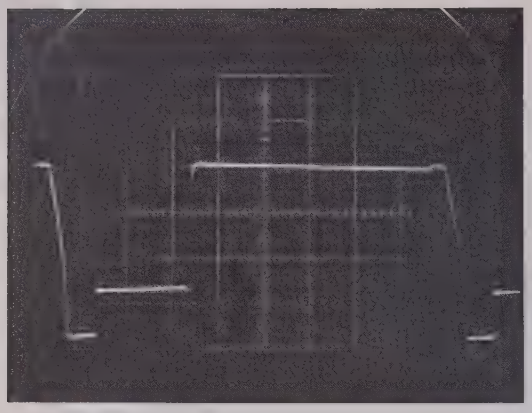


5. IC 201, Pin 2
5V/CM-20m Sec/CM

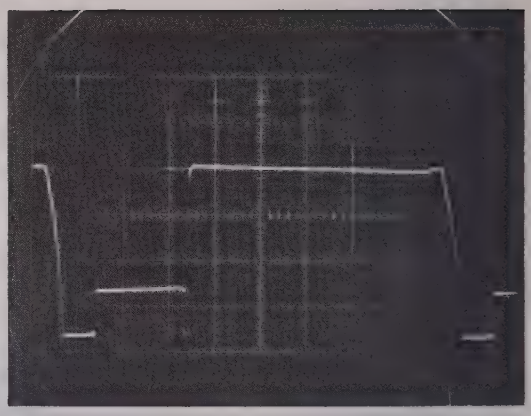


6. IC 201, Pin 6
5V/CM-20m Sec/CM

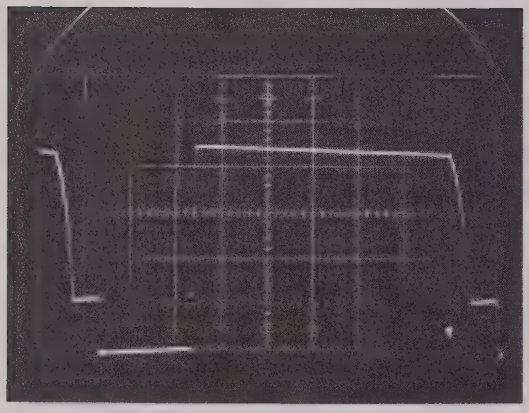
FIGURE 5-7 TYPICAL WAVEFORMS



7. Q 206, Collector
.5V/CM-20m Sec/CM-AC
Coupled



8. Q 209, Collector
.5V/CM-20m Sec/CM-AC
Coupled



9. Q 207, Collector
.5V/CM-20m Sec/CM-AC
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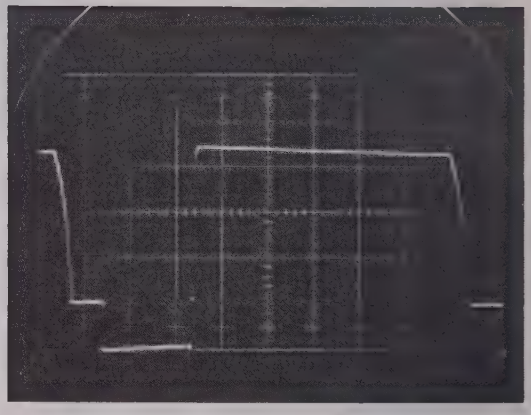
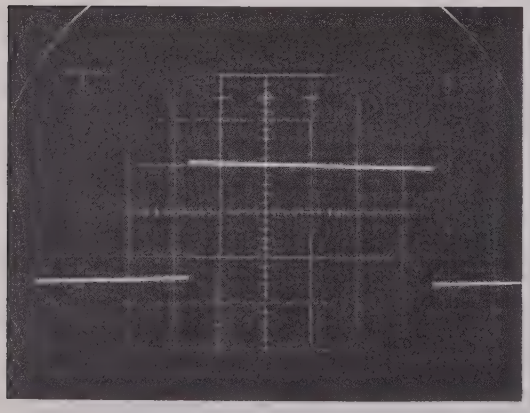
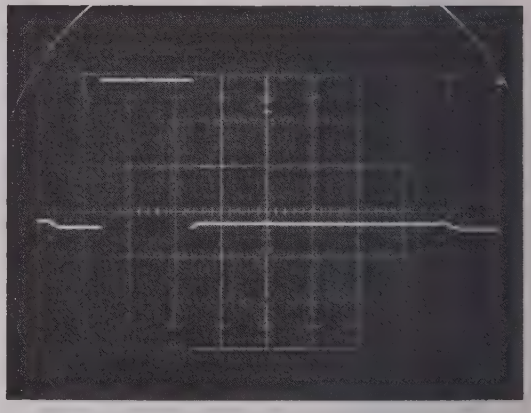


10. Q 210, Collector
.5V/CM-20m Sec/CM-AC
Coupled

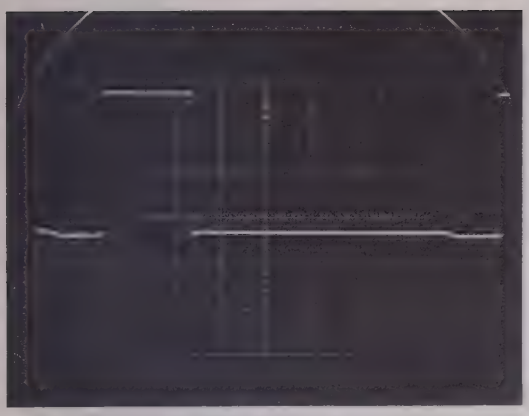


11. Q 212 Collector
.2V/CM-20M Sec/CM-AC
Coupled

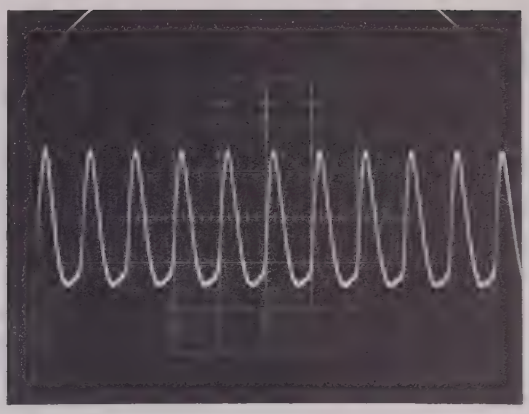


12. IC 202, Pin 7
1V/CM-20m Sec/CM

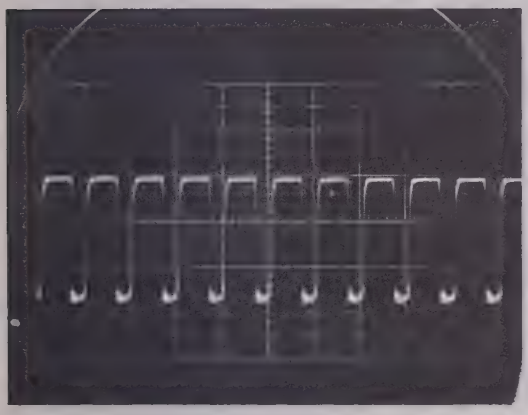
FIGURE 5-7 TYPICAL WAVEFORMS (Continued)



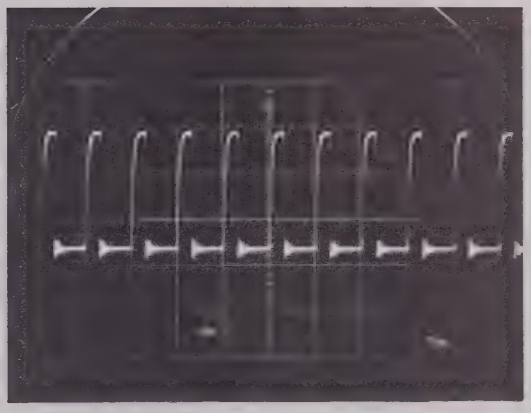
13. IC 203, Pin 7
1V/CM-20m Sec/CM



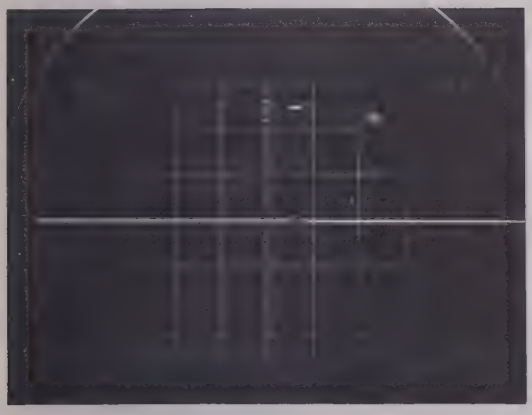
14. Q 214, Emitter
.2V/CM-1 u Sec/CM-AC
Coupled



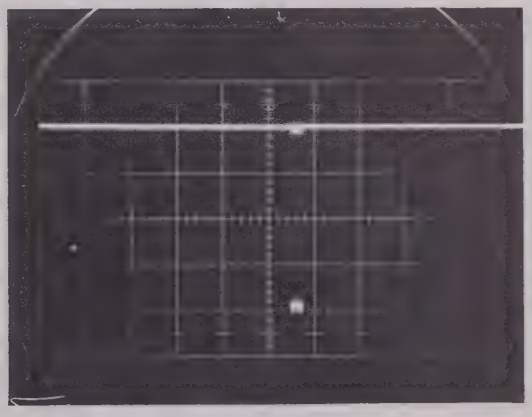
15. Q 215, Collector
.5V/CM-1 u Sec/CM-AC
Coupled



16. IC 206, Pin 13
2V/CM-1 u Sec/CM-AC
Coupled



17. IC 206, Pin 12
2V/CM-5m Sec/CM

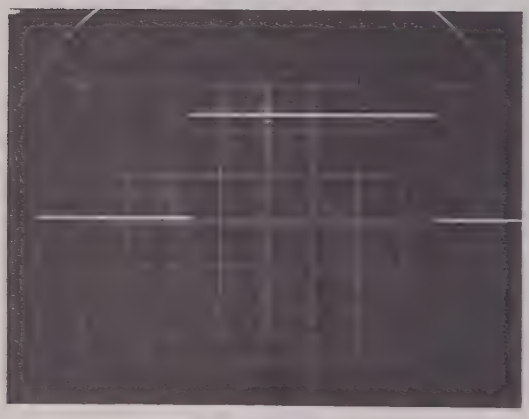


18. IC 206, Pin 11
1V/CM-5m Sec/CM-AC
Coupled

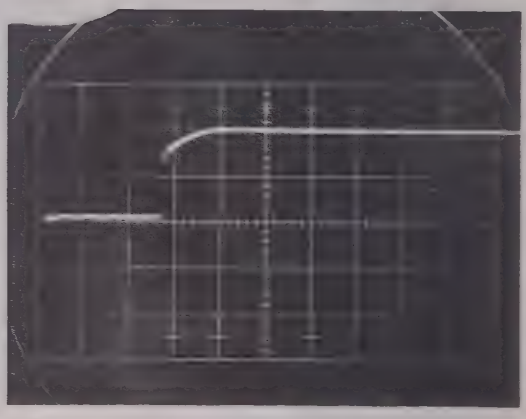
FIGURE 5-7 TYPICAL WAVEFORMS (Continued)

19. IC 206, Pin 2
2V/CM-20m Sec/CM

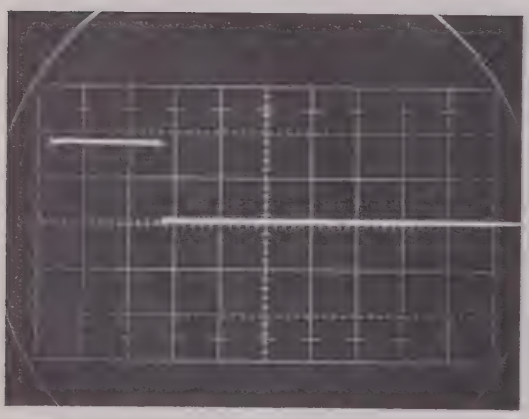
20. IC 205, Pin 3
2V/CM-20m Sec/CM



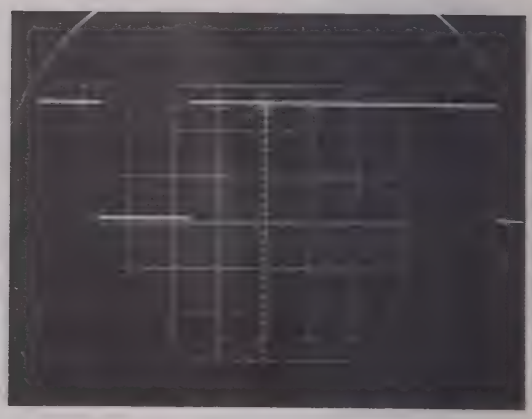
21. IC 206, Pin 5
2V/CM-20m Sec/CM



22. IC 206, Pin 6
2V/CM-1 u Sec/CM

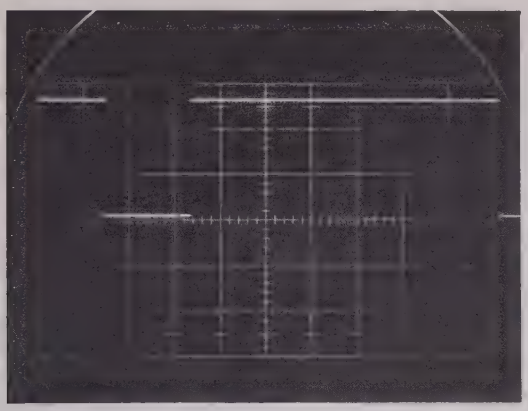


23. IC 206, Pin 8
2V/CM-1 u Sec/CM

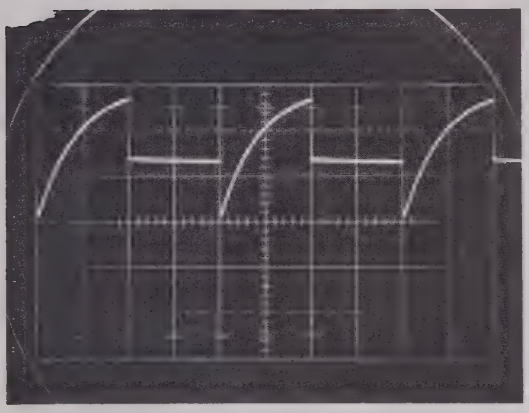


24. IC 204, Pin 12
2V/CM-20m Sec/CM

FIGURE 5-7 TYPICAL WAVEFORMS (Continued)



25. IC 204, Pin 13
2V/CM-20m Sec/CM



26. Neon Multfvibrator
D.C. Amplifier, Point A
(See Figure 5-4)
50V/CM-1m Sec/CM

NOTES:

1. **All waveforms are D.C. coupled unless otherwise stated.**
2. **Oscilloscope external trigger taken from 1C205, Pin 2.**
3. **Oscilloscope reference is indicated by the letter R.**

FIGURE 5-7 TYPICAL WAVEFORMS (Continued)

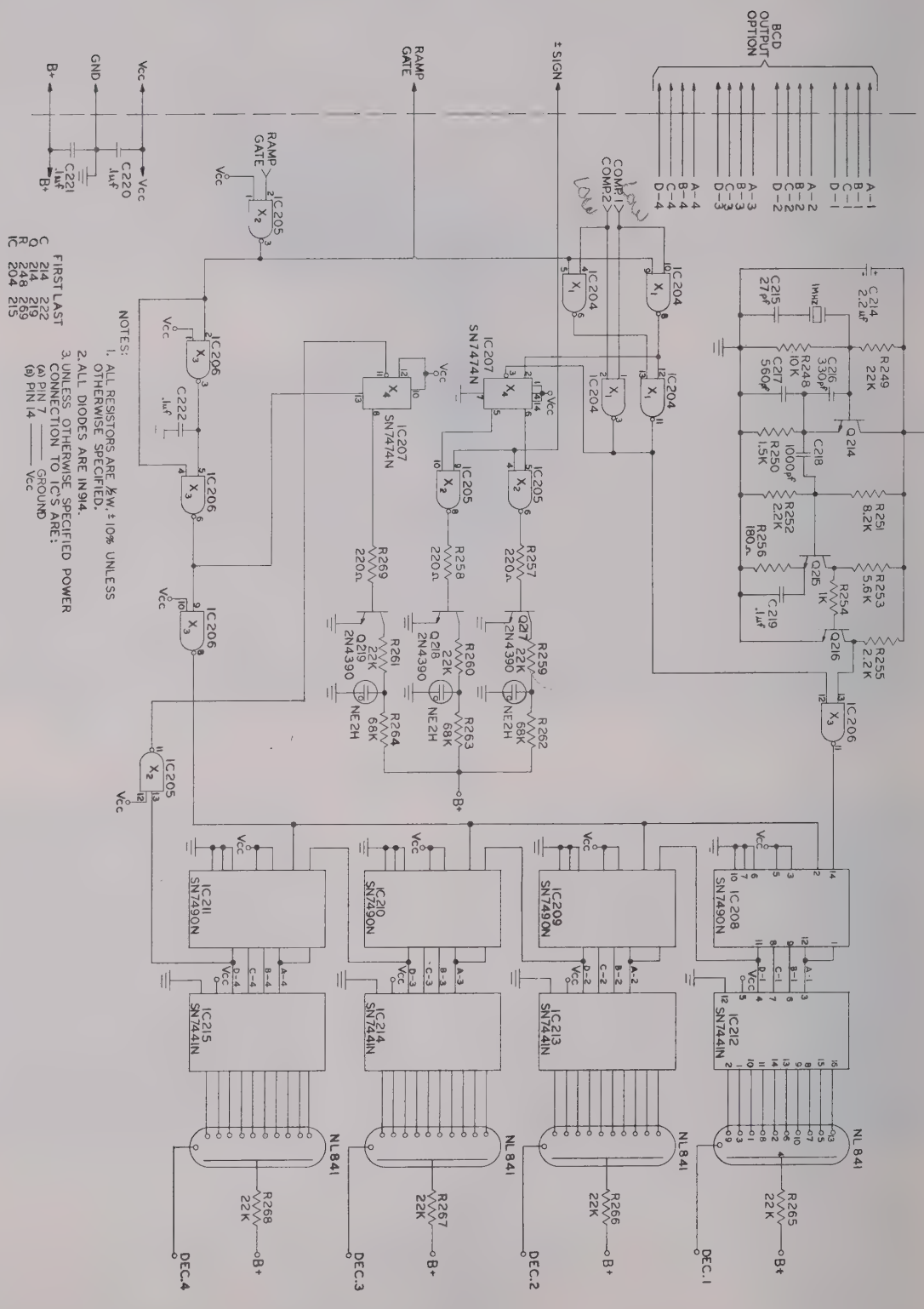


FIGURE 5-8A SCHEMATIC DIAGRAMS MODEL 2700-A CONTROL BOARD

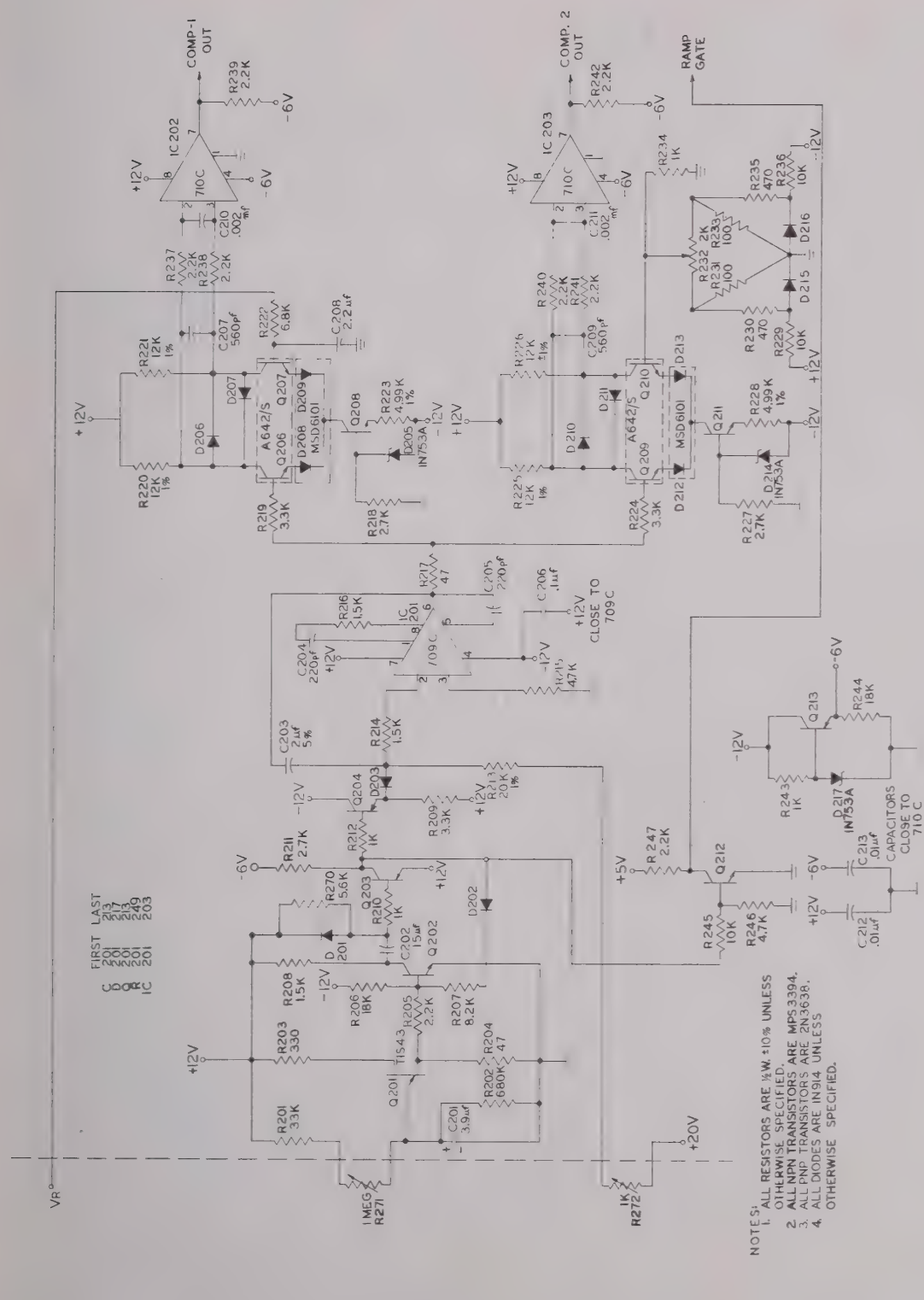


FIGURE 5-8B SCHEMATIC DIAGRAMS (Continued)
MODEL 2700-A CONTROL BOARD

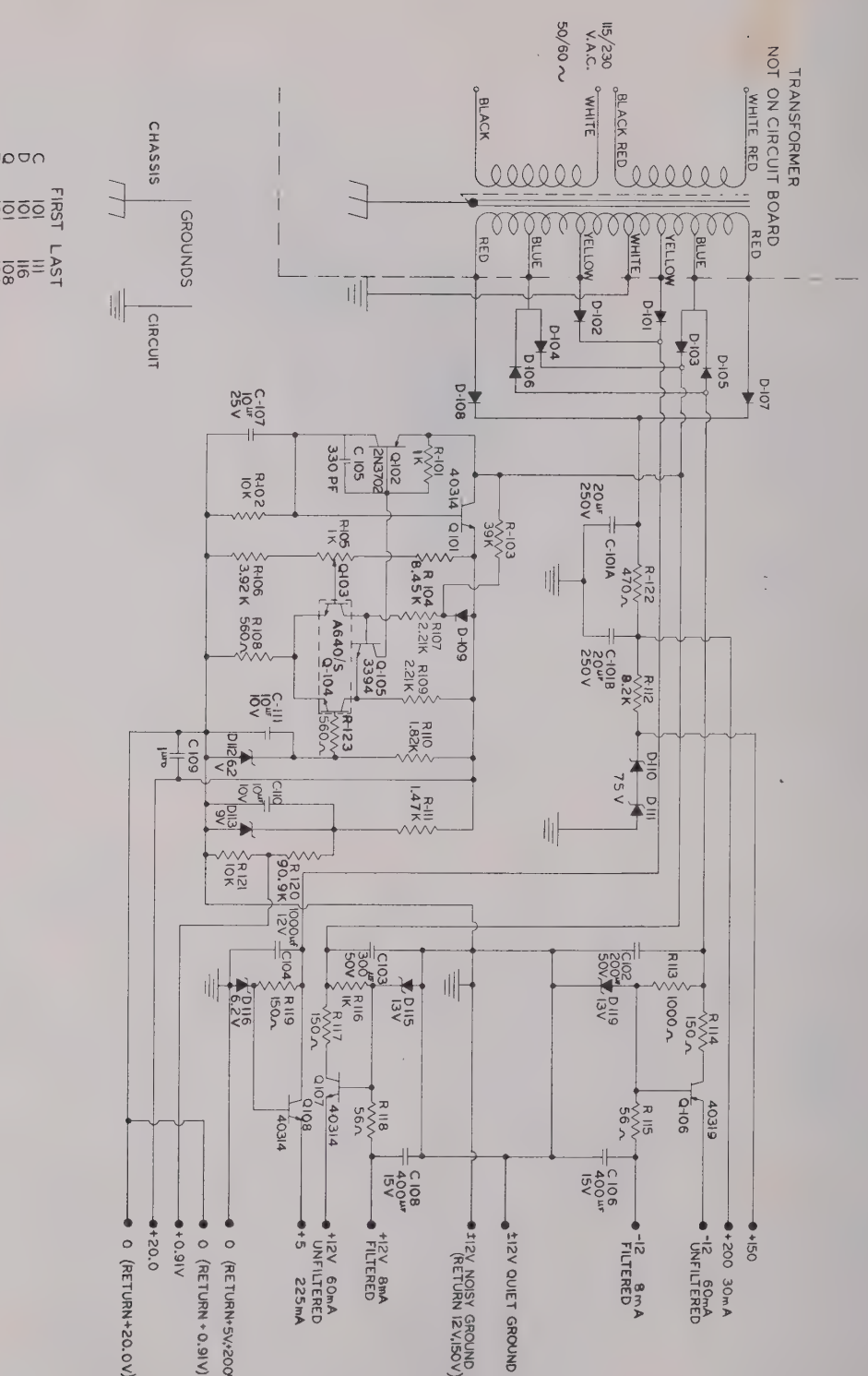


FIGURE 5-8C SCHEMATIC DIAGRAMS (Continued)
MODEL 2700-A POWER SUPPLY

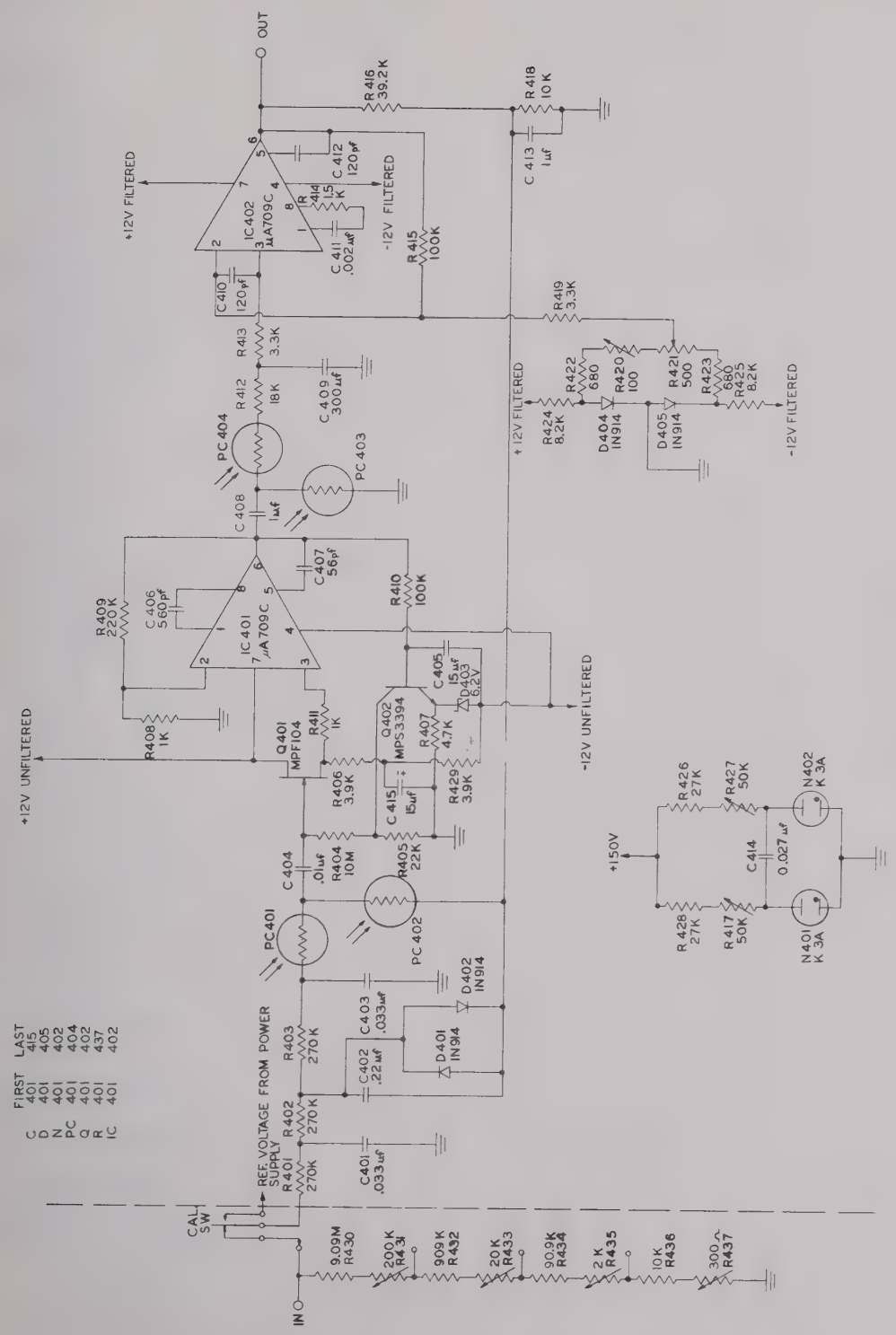


FIGURE 5-8D SCHEMATIC DIAGRAMS (Continued)
MODEL 2700-A D.C. AMPLIFIER

SECTION VI
REPLACEABLE PARTS

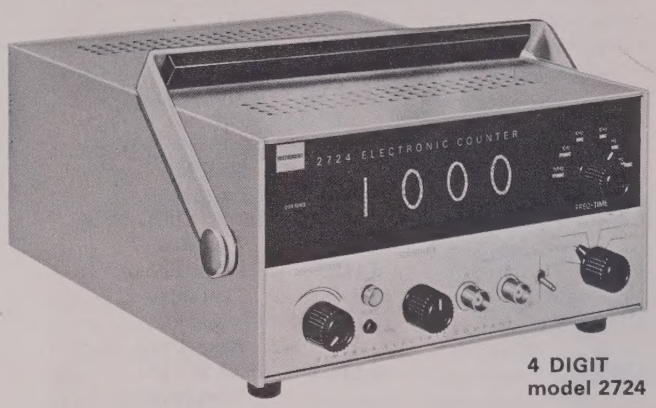
SYMBOL	PART NO.	DESCRIPTION
IC201, IC401, IC402	5-112683	Operational Amplifier
IC202, IC203	5-113332	Differential Comparator
IC204, IC205, IC206	5-112637	Quad 2-Input Gate
IC207	5-112682	Dual D Flip-Flop
IC208, IC209, IC210, IC211	5-112623	Decade Counter
IC212, IC213, IC214, IC215	5-112624	Decoder Driver
Q101, Q107, Q108	5-112704	Transistor, NPN, 40314
Q106	5-112705	Transistor, PNP, 40319
Q102	5-112706	Transistor, PNP, 2N3702
(Q103, Q104)*	5-112807	Transistor, NPN
Q105, Q202, Q208, Q211, Q212, Q402	5-112631	Transistor, NPN, MPS3394
Q201	5-112685	Transistor, Unijunction
Q203, Q204, Q213	5-111841	Transistor, PNP, 2N3638
(Q206, Q207), (Q209, Q210)*	5-112633	Transistor, NPN
Q214, Q215, Q216	5-112684	Transistor, NPN, 2N3563
Q217, Q218, Q219	5-112632	Transistor, NPN, 2N4390
Q401	5-112747	Transistor, FET, MPF104
D101, D102, D103, D104, D105, D106	5-111843	Diode, Rectifier, 1N2482
D107, D108	5-112805	Diode, Rectifier
D109, D201, D202, D203, D206, D207, D210, D211, D215, D216, D401, D402, D404, D405	5-112004	Diode, Silicon, 1N914
D110, D111	5-112741	Diode, Zener, 1N4761A
D112	5-112721	Diode, Zener, 1N825
D113	5-112806	Diode, Zener, 1N937
D115, D119	5-112726	Diode, Zener, 1N4743A
D116	5-112804	Diode, Zener, 1N4735A
D205, D214, D217	5-112634	Diode, Zener, 1N7553A
(D208, D209), (D212, D213)†	5-112640	Diode, Dual Switching, MSD6101
D403	5-113365	Diode, Zener
R204, R217	1-113921	47 ohms ±10%, ½ watt
R115, R118	1-115388	56 ohms ±10%, ½ watt
R231, R233	5-110835	100 ohms ±10%, ½ watt
R119	1-113926	150 ohms ±10%, ½ watt
R114, R117	1-119573	150 ohms ±10%, 1 watt
R256	1-115387	180 ohms ±10%, ½ watt
R257, R258, R269	1-115612	220 ohms ±10%, ½ watt
R203	1-110645	330 ohms ±10%, ½ watt
R230, R235	1-113940	470 ohms ±10%, ½ watt
R112	5-112310	470 ohms ±10%, 1 watt
R108	5-112710	560 ohms ±2%, ¼ watt, Glass
R123	1-116899	560 ohms ±10%, ½ watt
R422, R423	1-118399	680 ohms ±10%, ½ watt
R101, R113, R116, R210, R212, R234, R243, R254, R408, R411	1-110644	1K ohms ±10%, ½ watt
R111	5-112815	1.47K ohms ±1%, ¼ watt, Metal film
R208, R214, R216, R250, R414	1-114681	1.5K ohms ±10%, ½ watt
R110	5-112814	1.82K ohms ±1%, ¼ watt, Metal Film
R205, R237, R238, R239, R240, R241, R242, R247, R252, R255	1-113941	2.2K ohms ±10%, ½ watt
R107, R109	5-112703	2.21K ohms ±1%, ¼ watt, Metal film
R211, R218, R227	1-113942	2.7K ohms ±10%, ½ watt
R209, R219, R224, R413, R419	1-114225	3.3K ohms ±10%, ½ watt
R406, R429	1-113045	3.9K ohms ±10%, ½ watt
R106	5-112702	3.92K ohms ±1%, ¼ watt, Metal film
R215, R246, R407	1-114058	4.7K ohms ±10%, ½ watt
R223, R228	5-113333	4.99K ohms ±1%, ¼ watt, Metal film
R253, R270	1-114465	5.6K ohms ±10%, ½ watt
R222	1-113048	6.8K ohms ±10%, ½ watt
R207, R251, R424, R425	1-113050	8.2K ohms ±10%, ½ watt
R112	5-112978	8.2K ohms ±10%, 1 watt
R104	5-112701	8.45K ohms ±1%, ¼ watt, Metal film
R121, R418, R436	5-112731	10K ohms ±½ %, ¼ watt, Metal film
R102, R229, R236, R245, R248	1-111671	10K ohms ±10%, ½ watt
R220, R221, R225, R226	5-112689	12K ohms ±1%, 1/8 watt, Metal film
R206, R244, R412	1-113943	18K ohms ±10%, ½ watt
R213	5-112688	20K ohms ±1%, ¼ watt, Metal film
R249, R259, R260, R261, R265, R266, R267, R268, R405	1-113439	22K ohms ±10%, ½ watt
R426, R428	1-113944	27K ohms ±10%, ½ watt
R201	1-113945	33K ohms ±10%, ½ watt
R103	1-115613	39K ohms ±10%, ½ watt
R416	5-112730	39.2K ohms ±½%, ¼ watt, Metal film

† Matched pair in one package

*Matched Pair

SYMBOL	PART NO.	DESCRIPTION
R262, R263, R264	1-114803	68K ohms ±10%, ½ watt
R120, R434	5-112742	90.9K ohms ±½%, ¼ watt, Metal film
R410, R415	1-113949	100K ohms ±10%, ½ watt
R409	5-111116	220K ohms ±10%, ½ watt
R401, R403, R420	1-115497	270K ohms ±10%, ½ watt
R432	5-112744	909K ohms ±½%, ¼ watt, Metal film
R430	5-112743	9.09 Megohms ±½%, ¼ watt, Metal film
R404	5-111117	10 Megohms ±10%, ½ watt
R420	5-113011	Potentiometer, 100 ohms
R437	5-112714	Potentiometer, 300 ohms
R421	5-113010	Potentiometer, 500 ohms
R272	5-112755	Potentiometer, 1K Multi-turn
R105	5-112708	Potentiometer, 1K Multi-turn
R435	5-112717	Potentiometer, 2K Multi-turn
R232	5-111709	Potentiometer, 2K Multi-turn
R433	5-112713	Potentiometer, 20K Multi-turn
R417, R427	5-112716	Potentiometer, 50K Multi-turn
R271	5-112712	Potentiometer, 1 Megohm, with SPST Switch
C215	5-112692	27 pf
C407	5-110934	56 pf
C410, C412	5-111432	120 pf
C204, C205	5-112691	220 pf
C105, C216	5-112690	330 pf
C207, C209, C217, C406	5-112695	560 pf
C218	1-115652	1000 pf
C210, C211, C411	5-111426	.002 uf
C212, C213, C404	5-112694	.01 uf
C414	5-113366	.027 uf
C401, C403	5-112751	.033 uf
C206, C219, C220, C221, C222	5-110732	.1 uf
C402	5-110734	.22 uf
C109, C408, C413	5-112753	1.0 uf
C203	5-112698	2.0 uf, 5%, 100VDC, 50PPM
C208	5-112979	2.2 uf
C214	5-112693	2.2 uf, ±10%, 2-VDC, Tantalum
C201	5-112697	3.9 uf, ±10%, 20VDC, Tantalum
C110, C111	5-112719	10 uf, 10VDC, Electrolytic
C107	5-112720	10 uf, 25VDC, Electrolytic
C202	5-112696	15 uf, ±10%, 20VDC, Tantalum
C405, C415	5-112800	15 uf, ±20%, 10VDC, Tantalum
C101	5-112808	20-20uf, 250VDC, Dual Electrolytic
C102	5-112809	200 uf, 50VDC, Electrolytic
C103	5-112811	300 uf, 50VDC, Electrolytic
C409	5-112749	300 uf, −10−150%, 10VDC non-polar, Electrolytic
C106, C108	5-112810	400 uf, 15VDC, Electrolytic
C104	5-112812	1000uf, 12VDC, Electrolytic
N401, N402	5-112739	Lamp, Neon, K3A
	5-111505	Lamp, Neon, NE2H
PC401, PC402	5-112738	Photocell VT21M
PC403, PC404	5-112737	Photocell, VT21K
	5-112834	Transformer, Power
	5-112748	Cord, Power
	10-861685	Board, D.C. Voltage, Plug-in
	10-861684	Board, D.C. Amplifier
	10-861769	Board, Digital & Control
	10-861686	Board, Power Supply

NEW! DIGITAL ELECTRONIC COUNTERS
models 2724 and 2725



4 DIGIT
model 2724

5 DIGIT
model 2725

INTEGRATED CIRCUITS

For compactness and reliability

- **ACCURACY WITHIN ±0.01% ±1 DIGIT**
- **6 SWITCH SELECTED TIME BASES**
- **DIRECT FREQUENCY READOUTS UP TO 20 MHz**

New I/C digital counters measure average frequency (up to 20 MHz), time interval, period, and frequency ratio, plus totalizing pulses over a selected time period. Front panel switch provides thorough check of logic circuitry. 6 time bases are switch selected. The internal clock is crystal controlled for accuracy. Overrange and Gate Time indications are fully automatic. Top quality components combined with Simpson's strict manufacturing controls assures ±.01% ±1 digit accuracy, over a temperature range of +15°C to +55°C.

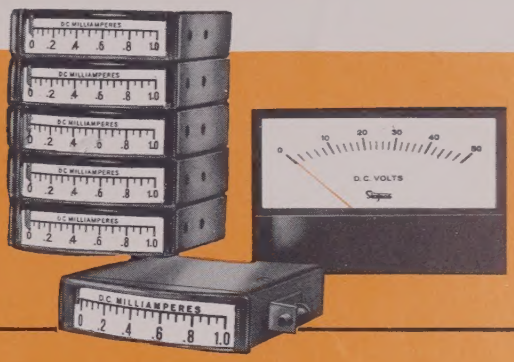
SPECIFICATIONS

Ranges	2724	2725
Frequency	5 Hz to 20 MHz	
Period	300 μ seconds to 0.2 seconds	
Frequency Ratio	1 to 1.9999 x 10^4	1 to 1.99999 x 10^5
Time Interval	300 μ seconds to 1.9999 x 10^4	300 μ seconds to 1.99999 x 10^5
Totalization	0 to 1.9999 x 10^4 counts	0 to 1.99999 x 10^5 counts
Accuracy	±0.01%, ±1 digit	
Temperature Range	+15°C to +55°C	
Number of Full-time Digits	4	5
Time Bases	0.1, 1.0, and 10.0 milliseconds; 0.1, 1.0, and 10.0 seconds	
Display Time	Adjustable from approx. 2 per second to "hold"	
Input Impedance		
Channel A	1 Megohm shunted by 30 pf	
Channel B	10 K ohms shunted by 30 pf	
Input Coupling	AC	
Input Sensitivity		
Channel A	0.1 volt RMS minimum from 30 Hz to 20 MHz. 0.5 volt RMS minimum from 5 Hz to 30 Hz.	
Channel B	0.1 volt RMS minimum from 200 Hz to 1 MHz. 0.5 volt RMS minimum from 5 Hz to 200 Hz.	
Max. Permissible Input Voltage	250 volts RMS	
Power Required	115 or 230 volts AC ±10%, 50 to 60 Hz, at approximately 17 watts	
Weight	8 pounds	
Size	4 x 8¼ x 11 inches	
Readouts	Cold gas glow tubes, 200,000 hour rated life	
Circuitry	Solid-state and integrated circuits	

if your meter problem is . . .

space . . .

Small Panel Area Meters—Miniature, stackable, edgewise meters—and Simpson's new minimum-height Designer Series.

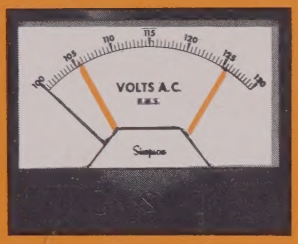


time . . .

Elapsed Time Meters—Matching panel meter styles, in 110 and 220 volt stock models.

control . . .

Meter Relays—Contactless and contact types, one and two control point models.



environment . . .

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